Heterogeneous Paths of Structural Transformation †

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Abstract

I establish new facts and explanations on the heterogeneous paths of structural transformation across countries. First, many countries exhibit flat-manufacturing profiles without noticeable signs of deindustrialization, which differ from the conventional steep-manufacturing hump-shaped profiles in advanced economies. Second, substantial heterogeneity exists in the labor allocation within services sector as flat-manufacturing countries tend to allocate substantially more labor into low-skilled services compared to steep-manufacturing countries. Third, heterogeneous structural transformation paths are prevalent among both earlier and later developers and not subject to the timing of development. Using a standard model of structural transformation, I find that observed differences in sectoral productivity growth are not quantitatively sufficient to generate the heterogeneous paths of structural transformation across countries. Instead, differences in relative productivity levels between manufacturing and low-skilled services account for around the majority, around 70%, of the heterogeneity, suggesting that country-specific factors are key. I show that the observed heterogeneous paths of structural transformation contribute substantially to economic growth outcomes across countries.

JEL classification: E1, E24, O11, O13, O14, O41, O50.
Keywords: employment, agriculture, manufacturing, low-skilled services, high-skilled services, productivity, structural transformation, industrialization, premature deindustrialization.

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1 Introduction

Structural transformation—the reallocation of resources across broad economic sectors—is a prominent feature of economic development. One common pattern of structural transformation is the hump-shaped evolution of manufacturing sector: rise at early stages of development (industrialization), reach a peak and then decline at later stages (deindustrialization). Rodrik (2016) observes that many recent developers experience a substantially lower value of the peak and attain the peak at a lower level of development compared to earlier developers, referring to this phenomenon as "premature deindustrialization."

What are the driving forces of "premature deindustrialization"? Rodrik (2016) first suggests that deindustrialization has been rising on a global scale in recent decades due to the trend of globalization and labor-saving technological progress in manufacturing. This means recent emerging countries are running out of industrialization opportunities and consequently facing lower economic growth compared to earlier developers. Later work by Huneeus and Rogerson (2023) attributes the "premature deindustrialization" to the countries' rates of convergence to the frontier countries. In particular, they suggest that low growth in agricultural productivity is the main factor behind this phenomenon. Different from the conclusions of these two earlier papers, this paper uncovers new findings that provide novel insights on the sources behind the "premature deindustrialization" phenomenon. I find that the heterogeneity in structural transformation patterns occurs among both earlier and later developers and is not simply subject to the timing of development. The heterogeneity is found to be mainly driven by the difference in relative productivity levels between manufacturing and low-skilled services, which might reflect the difference in endowments and distortions specific to each individual country.

I start by documenting a set of stylized facts on the heterogeneity in structural transformation across countries. Using data from the Groningen Growth and Development Centre (GGDC) 10-Sector Database and the Penn World Table (PWT) 10.0, I document the following stylized facts. First, a number of countries experience a flat profile of the manufacturing employment share without a noticeable peak over the course of development. This pattern of flat-manufacturing profiles is different from the conventional steep hump-shaped pattern in the manufacturing employment share documented in the United States and many other advanced countries. Second, there also exists much heterogeneity in the types of services expanded between advanced countries and the countries experiencing flat-manufacturing profiles. While the advanced countries tend to develop high-skilled services, the flat-manufacturing countries allocate much more labor into low-skilled services. Third, heterogeneous paths of structural transformation are prevalent among both early and late developers. The third fact provides evidence suggesting that the heterogeneous paths of structural transformation cannot be simply attributed to timing of development and explained by changes in global economy over time (such as technological changes and globalization trend) as suggested by Rodrik (2016). These three stylized facts motivate the two research questions of this paper. What are the key sources driving heterogeneous paths in structural transformation across countries? What are the aggregate implications of this heterogeneity on growth and development?

The multisectoral general equilibrium model in this paper features two standard forces driving structural transformation in the existing literature: income and substitution effect. Similar to Duarte and Restuccia (2010) and Huneeus and Rogerson (2023), household has Stone-Geary preference over agriculture and non-agricultural consumption. Labor reallocation out of agriculture in the model is mainly driven by the income effect and determined by agricultural productivity. Regarding non-agricultural sectors, following Comin et al. (2021), households have non-homothetic constant-elasticity-of-substitutition (CES) preferences over manufacturing and the two services sectors. Labor allocation between manufacturing and the services sectors are affected by sectoral labor productivity levels through both income and substitutition effect channels. The model consists of four sectors with the disaggregation of services into low-skilled and high-skilled services instead of the standard single services sector, and is calibrated to match the evolution of the sectoral employment shares in the United States during the early to middle stages of development. Following Duarte and Restuccia (2010), due to the lack of comparable sectoral output data across countries, the cross-country calibration involves the inference of sectoral productivity levels in the model to match sectoral employment shares and aggregate labor productivity levels. As a validation check for the model, I compare the sectoral productivity growth rates inferred by the model with the observed growth rates in the data. The model exhibits a good fit and well captures structural transformation patterns across countries.

Through the lens of the benchmark model, I find that sectoral productivity profiles are driven by two forces: sectoral productivity growth rates (dynamic factors) and initial sectoral productivity levels (static factors). Specifically, if two economies experience identical sectoral productivity growth rates but differ in sectoral productivity levels at the same level of development (e.g., the same level of agricultural employment share), their sectoral productivity profiles will be persistently different. In this paper, I refer to the persistent differences in manufacturing and services sector productivity profiles at the initial development level (e.g. 50% agricultural employment share) as differences in initial sectoral productivity levels (static factors). Huneeus and Rogerson (2023) emphasize the sectoral productivity growth rates (dynamic factors) in their analysis. The key novel contribution of this paper is to uncover the role of the initial sectoral productivity levels (static factors) in driving the structural transformation pattern. Using the calibrated model to the United States, I perform counterfactuals assuming the sectoral productivity growth rates of the United States but changing the relative productivity levels between manufacturing and low-skilled services during the initial period when the agricultural employment share was 50%. By lowering the initial relative productivity level of low-skilled services relative to manufacturing, the counterfactuals generate structural transformation patterns very close to the patterns observed in most of the flat-manufacturing countries. The counterfactual result suggests that deviation in the sectoral productivity growth rates from the United States' growth rates are not large enough to quantitatively generate the patterns observed in the flat-manufacturing countries. Instead of the sectoral productivity growth rates, variation in the initial relative productivity levels is suggested to be the determinant factors, accounting for around 70 percent of the observed heterogeneity in structural transformation paths across countries. The initial sectoral productivity levels reflect country-specific components that are persistent over the course of development.

This finding raises a question of why the relative productivity level of low-skilled services to manufacturing is so much lower in the flat-manufacturing countries. I document cross-country evidence that the degree of informality has a dominant role in low-skilled services compared to manufacturing. Moreover, countries with the flat-manufacturing profile also tend to have a larger informal sector. The evidence suggests that country-specific distortions (such as business entry and operation costs) leading to a high degree of informality could be a potential source of low productivity level of low-skilled services relative to manufacturing in the flat-manufacturing countries. Differences in human capital (education or schooling) are found to have limited relationship with structural transformation patterns across countries.

I then use the model to assess the aggregate implications of the heterogeneous paths of structural transformation. During the period from 1965 to 2010, most steep-manufacturing countries experience substantial catch-up episodes in aggregate labor productivity relative to the United States, whereas the flat-manufacturing countries experience stagnation and slowdown. To study the aggregate implications of heterogeneous sectoral productivity patterns, I perform four sets of counterfactuals by setting productivity growth rate to the United States rate for each sector among agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactuals indicate that productivity growth in agriculture and high-skilled services sectors have little impact on aggregate productivity. The catch-up experiences in the steep-manufacturing countries are mostly associated with the catch-up in manufacturing productivity. Stagnation experiences in the flat-manufacturing are mainly attributed to the low productivity growth and the dominant size of low-skilled services sector.

This paper is related to a broad literature studying structural transformation.[1] In particular, it directly links to the recent literature studying the heterogeneous patterns in the industrialization and the deindustrialization. There are several important papers proposing alternative channels explaining the heterogeneity in the industrialization experiences across countries. The paper is highly relevant to Rodrik (2016) and Sposi et al. (2021). Rodrik (2016) observes that the peak of the manufacturing hump-shaped pattern is lower and occurs at a lower level of development post-1990s compared to pre-1990s, a phenomenon termed "premature deindustrialization". This trend is attributed to the rise of globalization and labor-saving technological advancements in manufacturing. Sposi et al. (2021) provides further evidence supporting this phenomenon. However, through the lens of a dynamic open-economy structural transformation model, they emphasize the importance of changes in sectoral productivity growth in explaining this phenomenon. Additionally, they introduce a new phenomenon called "industry polarization," which describes the cross-country dispersion of manufacturing shares over recent decades, attributing it to the trend of global trade integration. Both of these papers primarily address the temporal aspect of heterogeneity. They categorize the sample countries into two main groups based on the timing of development: pre-1990 (early developers) and post-1990 (late developers), focusing on analyzing the differences between these two groups on average. Taking a different approach, my paper uncovers substantial heterogeneity in structural transformation patterns across countries within both the early and late developers. Among early developers, there exist both steep and flat manufacturing patterns, and similarly among late developers. This suggests that heterogeneity in structural transformation, including premature deindustrialization, is not exclusive to the post-1990 period; substantial differences in structural transformation paths exist within the same time periods. Furthermore, while the aforementioned papers concentrate on the manufacturing sector, my paper extends the analysis to capture the heterogeneity in both manufacturing and within services sectors across countries. Additionally, while they focus on open-economy setting, my paper focuses on closed-economy context.

My paper is also related to the literature studying skill-biased structural transformation. Recent papers by Buera et al. (2021) and Ngai and Sevinc (2020) document skill-biased

[1] See Herrendorf et al. (2014) for overview of structural transformation literature. Examples of important contributions are Kongsamut et al. (2001), Gollin et al. (2002, 2007), Ngai and Pissarides (2007), Buera and Kaboski (2009), Duarte and Restuccia (2010), Boppart (2014) and Comin et al. (2021).

structural transformation patterns as the reallocation process from low skill intensive sectors to high skill intensive sectors. Buera et al. (2021) and Ngai and Sevinc (2020) find that skilled-biased structural change is crucial to explain the patterns of rising wages for high-skilled workers and stagnation in wages for low-skilled workers in advanced economies. While these two papers concentrate on the two-sector disaggregation (high-skilled and low-skilled economic sectors) and its implications on labor market outcomes in high-income economies, my paper instead focuses on disaggregation within services sector (high-skilled and low-skilled services sectors) and its implications for the aggregate growth in middle-income economies. My paper also contributes to the recent literature investigating the heterogeneity within services sector and its implications on structural transformation and economic growth. Duarte and Restuccia (2020) show that substantial heterogeneity between traditional and non-traditional services has a large role in explaining cross-country income differences. Duernecker et al. (2021) disaggregate services into progressive and stagnant services. They show that large heterogeneity in productivity growth within services is important in understanding the productivity growth slowdown in the United States. The closest to my paper in this strand of the literature is Fang and Herrendorf (2021) which study the structural transformation between goods, low-skilled services and high-skilled services sectors in the context of China. Fang and Herrendorf (2021) find that underdevelopment of high-skilled services results from large distortions in this sector and results in substantial loss in China's aggregate productivity. Different from Fang and Herrendorf (2021), my paper investigates the heterogeneous structural transformation patterns in manufacturing and within services in a multi-country setting.

The paper is organized as follows. Section 2 describes the data and the data sources. In Section 3, I document a set of stylized facts on heterogeneous patterns in structural transformation across countries. Section 4 sets up a four-sector model of structural transformation and calibrates to the United States as a benchmark economy. Section 5 performs cross-country calibration and counterfactual analysis to assess the role of sectoral productivity factors in capturing the documented heterogeneity in cross-country structural transformation. In Section 6, I document patterns in aggregate productivity growth and use the model to investigate the implications of sectoral productivity across countries. Section 7 provides suggestive evidence and discussion on potential sources of explanations. Section 8 concludes.

2 Data

The main set of countries and periods in this analysis is from the GGDC 10-Sector Database (Timmer et al., 2015). Among the 41 countries in the sample, I exclude 8 countries that only experience a rise in manufacturing throughout the sample periods (industrialization) and 5 other countries that mostly experience decline in manufacturing throughout the sample periods (deindustrialization). 6 countries are excluded due to data issues. The analysis in this paper focuses on the group of the remaining 22 countries consisting of Argentina, Bolivia, Botswana, Brazil, Chile, Colombia, Costa Rica, France, Ghana, Indonesia, Italy, Japan, Korea, Malaysia, Mauritius, Mexico, Peru, Philippines, South Africa, Spain, Taiwan and the United States.

I aggregate the ten sectors into four using the following method. Manufacturing comprises of Mining and Quarrying; Manufacturing; Electricity, Gas and Water supply; and Construction. Services sector is disaggregated into low-skilled and high-skilled services following the standard classification in Buera et al. (2021), Ngai and Sevinc (2020) and Fang and Herrendorf (2021). A sub-service sector is defined as low-skilled service if its hour share of skilled labor is lower than the median of the broad services sector.[2] From the data on labor hours by skills, I compute hour share of high-skilled labor for each economic sector across of 26 European countries together with the United States and Japan during the period 1970-2004 from the KLEMS 2007 Database (Timmer et al., 2007). Economic sectors in the GGDC 10-Sector Database and the KLEMS 2007 Database are defined based on the International Standard Industrial Classification, Revision 3.1 (ISIC Rev.3.1). The disaggregation results are impressively consistent across countries and over time (see Figure A.1). Classification using labor compensation by skills instead of hours also yields similar results (see Figure A.2). The final classification is determined based on the majority of countries in the sample as follows. Low-skilled services consists of Trade Services (Wholesale and Retail Trade (G), Hotels and Restaurants (H)), Transport Services (Transport, Storage and Communications (I)), Personal Services (Other Community, Social and Personal Service Activities, Activities of Private Households (O,P)).High-skilled services includes Business Services (Financial Intermediation, Renting and Business Activities (excluding owner occupied rents) (J,K)), Government Services (Public Administration and Defense, Education, Health and Social work (L,M,N)).

This classification is similar to Fang and Herrendorf (2021)'s classification reported for China. Based on this classification, I compute the employment shares for the four sectors in

[2]Following the standard literature practice, skilled labor is defined as labor with college degree or higher.

each country and denote them as L_a, L_m, L_{ls}, L_{hs} for agriculture, manufacturing, low-skilled services and high-skilled services respectively. To analyze the trend of the series, I smooth the sectoral employment shares by standard practice using Hodrick-Prescott filter with a smoothing parameter value of 6.25 as in the standard practice. The data are merged with data from the Penn World Table (PWT) 10.0 (Feenstra et al., 2015) to study the aggregate implications of structural transformation patterns in Section 6. The PPP-adjusted measure of real aggregate output and the employment data are used to calculate real aggregate labor productivity.

For the structural transformation patterns in the United States, the GGDC 10-Sector Database only provides data after 1950 when the industrialization process in the United States was over. In order to fully capture both the industrialization and the deindustrialization phases in the United States, I combine data from 3 different sources: Carter et al. (2006) for the 1880-1930 period, Bureau of Economic Analysis (BEA) data for the 1929-1950 period and the GGDC 10-Sector Database for the 1950-2010 period.

To document the structural transformation patterns across recent (post-1990s) emerging countries reported in Section 3, I employ the GGDC/UNU-WIDER Economic Transformation Database (ETD) (de Vries et al., 2021). The database covers a broader set of 51 developing African, Asian and Latin American countries during period 1990-2018. Sectoral employment data are aggregated into four sectors in a similar manner as with the GGDC 10-Sector Database described earlier. Even though the industry classification of the GGDC/UNU-WIDER ETD is based on International Standard Industrial Classification, Revision 4 (ISIC Rev.4 Code), twelve economic sectors are aggregated into agriculture, manufacturing, low-skilled services and high-skilled services using a similar method.[3] Agriculture comprises of agriculture (A); manufacturing comprises of mining (B), manufacturing (C), utilities (D,E) and construction (F); low-skilled services comprise of trade services (G,I), transport services (H) and other services (R,S,T,U); high-skilled services comprise of business services (J,M,N), financial services (K), real estate (L) and government services (O,P,Q).

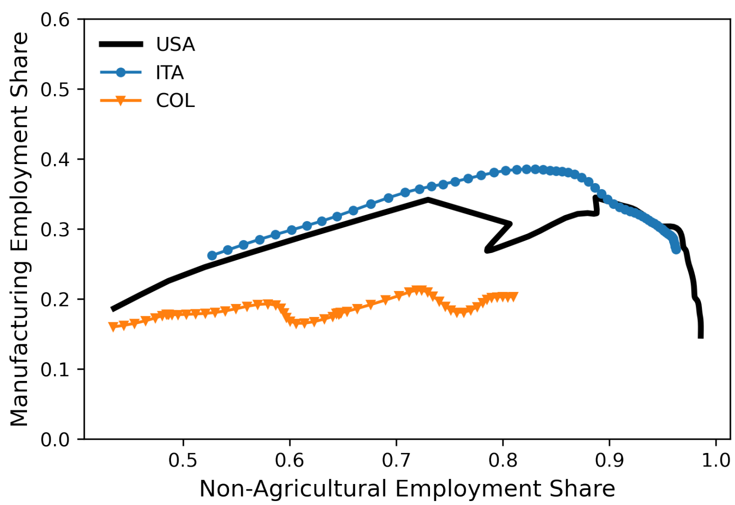
In Section 7, I use data on employment categorized by employment status and economic activity from International Labour Organization (ILO) Database. The dataset contains an unbalanced panel of 156 countries from 1976 to 2020. From the original dataset, I compute share of self-employed persons (serving as a proxy for degree of informality) by economic sector, country and year.

[3] The difference between the ISIC Rev.3.1 Code and the ISIC Rev.4 Code does not significantly affect the 4-sector classification into agriculture, manufacturing, low-skilled services and high-skilled services.

3 Heterogeneous Paths of Structural Transformation

Rodrik (2016) and Huneeus and Rogerson (2023) document large heterogeneity in the peak of the manufacturing hump-shaped patterns across countries. In this section, I document a more comprehensive set of facts uncovering new important features of heterogeneity in structural transformation. First, countries greatly differ in the whole profile of the manufacturing employment share: Some countries follow a steep rise and fall in the manufacturing employment share while many others follow a flatter manufacturing profile. Second, the heterogeneity is also substantial in the labor allocation within services. These two aspects of heterogeneity turn out to have an important role in understanding the explanatory sources as well as the implications on aggregate growth.

Figure 1: Heterogeneous Patterns of Structural Transformation



Notes: The sectoral employment data for the United States are from Carter et al. (2006), the Bureau of Economic Analysis and the GGDC 10-Sector Database covering the period 1880-2010. The sectoral employment data for Italy and Colombia are from the GGDC 10-Sector Database covering the period 1950-2010.

In order to compare the structural transformation patterns across countries, I employ a representation of plotting the sectoral employment shares over the non-agricultural employment share. This characterization yields an advantage of visualizing the labor reallocation process from agriculture towards manufacturing and services. As structural transformation out of agriculture is a robust feature of economic development, the non-agricultural employment share can serve as a proxy for the level of development. This representation of the sectoral employment shares over the non-agricultural employment share exhibits a very similar characterization to the conventional representation over GDP per capita.

Figure 1 plots the manufacturing employment share against the non-agricultural employment share of three countries: the United States, Italy and Colombia. The evolution profiles of the manufacturing employment shares are strikingly different between these countries. While the United States and Italy exhibit the steep inverted U-shaped pattern in manufacturing, Colombia shows the pattern of a flat hump-shaped profile in the manufacturing employment share. Next subsections present further cross-country evidence on this heterogeneity. To highlight the difference in the patterns of the manufacturing evolution, I classify countries into two groups of patterns: a steep-manufacturing group characterized by steep profile of manufacturing (similar to the United States and Italy) and a flat-manufacturing group characterized by a flat profile of manufacturing (similar to Colombia).

During the early to the middle stages of development, the flat-manufacturing countries allocate substantially less employment into manufacturing compared to the steep-manufacturing countries. Instead, the structural transformation in the flat-manufacturing countries is characterized by the reallocation of employment from agriculture into services. Do the flat-manufacturing countries allocate employment into the same types of services as steep-manufacturing? As sectors within services are widely different, disaggregation of service sector may reveal important implications about the structural transformation process and the growth experiences of the flat-manufacturing countries.

The following subsections present cross-country evidence that countries experience remarkably different patterns of structural transformation. Subsection 3.1 first shows the patterns in the United States as a benchmark and other countries in the steep-manufacturing group. Subsection 3.2 documents the patterns in the flat-manufacturing countries. Subsection 3.3 reports evidence that recent (post-1990s) emerging economies also exhibit substantial heterogeneity in the structural transformation patterns.

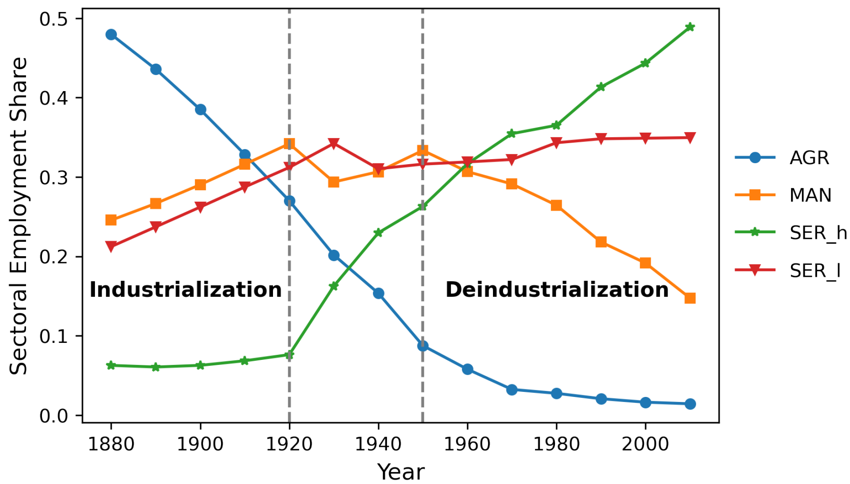
3.1 Pattern in Steep-Manufacturing Economies

This subsection presents stylized facts on structural transformation in the United States and many other countries exhibiting the similar pattern. I classify this type of structural transformation pattern as steep-manufacturing pattern.

Pattern in the United States

I first document the structural transformation in the United States as a benchmark economy. Figure 2 displays the evolution of the employment shares in manufacturing, low-skilled services and high-skilled services during the period from 1880 to 2010. The expansion of low-skilled and high-skilled services occurs at the different stages of development.

Figure 2: Structural Transformation in the United States during 1880-2010



Notes: The industrialization and the deindustrialization phase indicates the period observing significant rise and decline respectively in the manufacturing employment share. The period between 1920 and 1950 (Great Depression and World War II period) observes fluctuation in the manufacturing employment share.

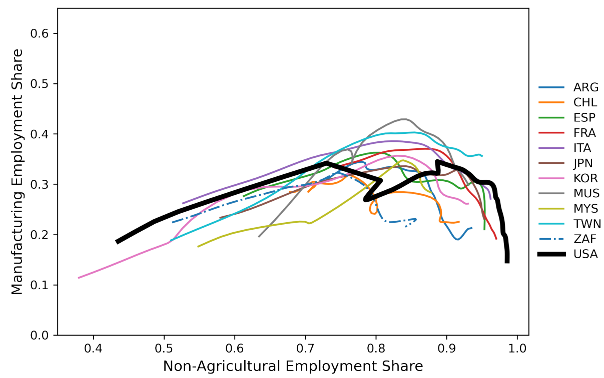
The structural transformation in the United States is characterized by three major phases. The industrialization phase (1880-1920) is characterized by the process of reallocating labor out of agriculture towards manufacturing and low-skilled services. The period between 1920 and 1950 (Great Depression and World War II period) observes fluctuation in the manufacturing employment share. The deindustrialization phase (1950-2010) follows with the decline in manufacturing and the rise of high-skilled services. The employment share in low-skilled services rises along with manufacturing at earlier stage when high-skilled services mostly develop and dominate the economy at later stage.

Pattern across Steep-Manufacturing Economies

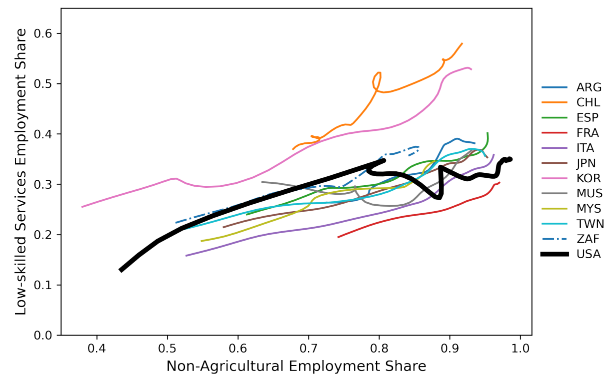
The structural change patterns are quite similar in other developed economies such as the United Kingdom, Canada, Italy and Japan (see Figure B.1). These developed economies experience a qualitatively similar pattern to the United States in the industrialization and the deindustrialization phases. Figure 3 documents the structural change pattern in the steep-manufacturing countries. The pattern is characterized by a steep hump-shaped evolution of the manufacturing employment share over the course of development. Low-skilled services rise along with manufacturing at earlier stage when high-skilled services mostly develop and dominate the economy at later stage. The structural transformation patterns differ significantly before and after the peak of manufacturing.

Figure 3: Structural Transformation in Steep-Manufacturing Economies

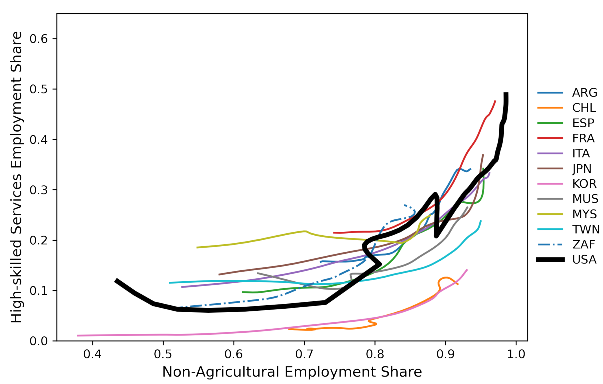
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

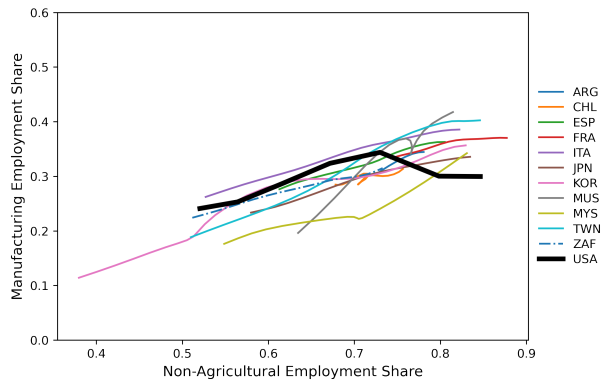


Notes: The solid black lines represent the evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over non-agricultural employment share in the United States as a benchmark. The slope of each line represents the percentage of the employment share reallocated to each sector given 1% of the total employment leaving agriculture.

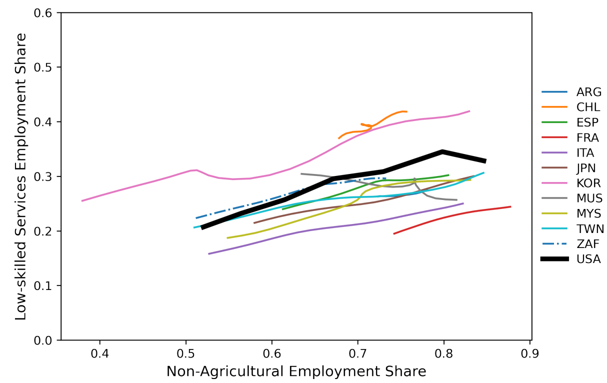
To better visualize the structural transformation patterns, I separate the sample period of all steep-manufacturing countries into two phases: the industrialization (before the manufacturing peak) and the deindustrialization (after the manufacturing peak). The employment shares in manufacturing, low-skilled services and high-skilled services are plotted against the non-agricultural employment share. Figure 4 and 5 present the evolution of the employment share in manufacturing, low-skilled services and high-skilled services during the industrialization and the deindustrialization phases respectively. These figures exhibit stark differences in the patterns of structural transformation between the industrialization and the deindustrialization phases.

Figure 4: Industrialization Phase of Steep-Manufacturing Economies

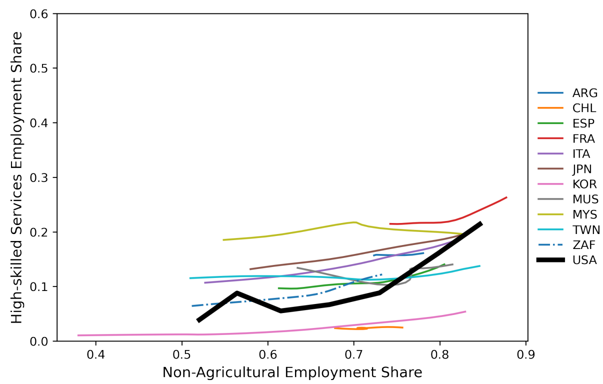
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

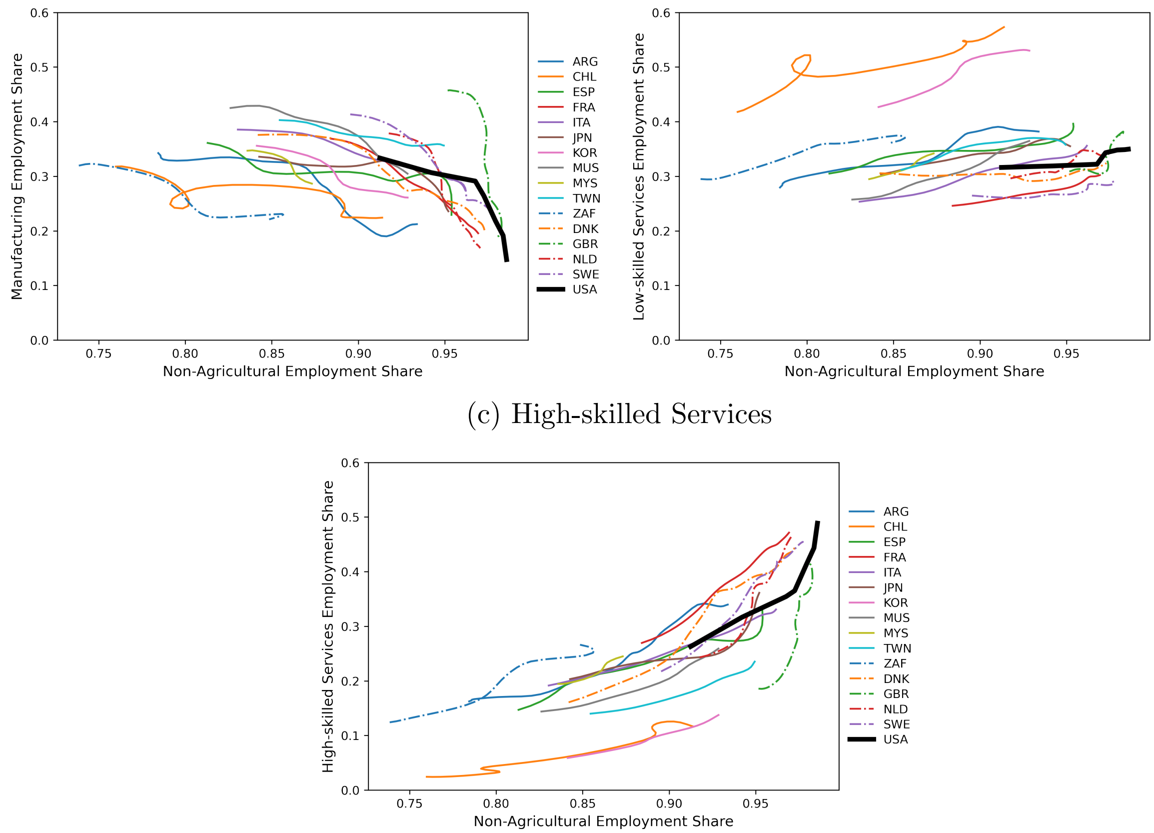


Notes: The industrialization phase for each country is marked as the period before the peak of the manufacturing employment share. For the United States, due to the period 1920-1950 with fluctuation in manufacturing employment share, the industrialization phase is chosen to be the period 1880-1950 before the decline of manufacturing employment share.

The industrialization phase is characterized by a reallocation of employment out of agriculture to manufacturing and low-skilled services. The sizes of manufacturing and low-skilled services sectors are comparable on average in this phase. The high-skilled services sector is smaller on average and exhibits larger variation across countries. During the industrialization phase (between 40% and 80% employment share in non-agricultural sector) in the United States, out of 1% employment share leaving agriculture, around 0.4%, 0.4% and 0.2% employment shares are reallocated to manufacturing, low-skilled services and high-skilled services respectively. The values of these slopes are quite similar in the other steep-manufacturing countries.

Figure 5: Deindustrialization Phase of Steep-Manufacturing Economies

(a) Manufacturing (b) Low-skilled Services



(c) High-skilled Services

Notes: The deindustrialization phase for each country is marked as the period after the peak of the manufacturing employment share. For the United States, due to the period 1920-1950 with fluctuation in the manufacturing employment share, the deindustrialization phase is chosen to be the period 1950-2010 during the decline of the manufacturing employment share.

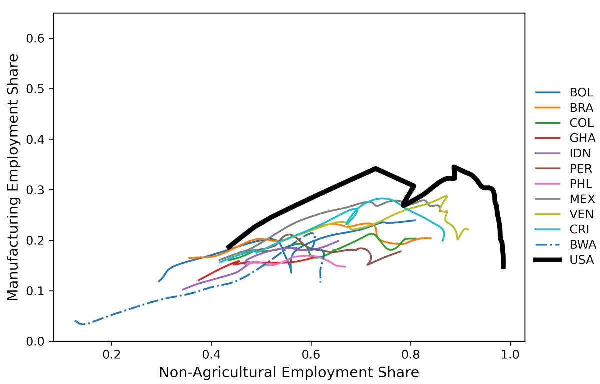
During the deindustrialization phase, the employment share in agriculture becomes minor. As discussed above, significantly different from the industrialization phase, the deindustrialization phase is marked with a sharp decline in the manufacturing employment share. Labor is reallocated towards high-skilled services, turning this sector to eventually become the largest sector in most developed countries. The low-skilled services employment share displays fewer changes during this phase.

3.2 Pattern in Flat-Manufacturing Economies

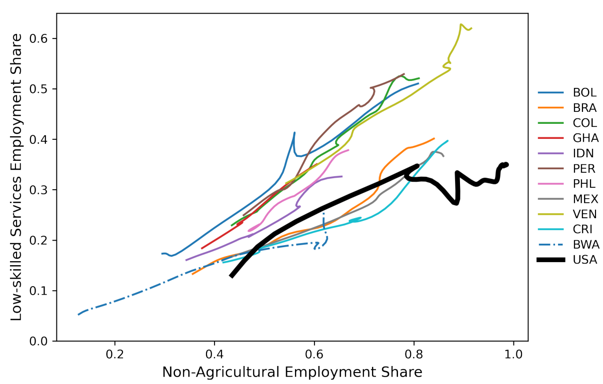
Flat-manufacturing countries do not observe significant deviation in structural transformation patterns before and after the manufacturing peak. I find that the evolution in the employment shares of low-skilled and high-skilled services exhibits similar trends before and after the manufacturing peak. Examples of countries which exhibit flat-manufacturing profile are Brazil, Peru, Philippines and Ghana (see Figure B.2). Unlike the steep-manufacturing countries including the United States, the flat-manufacturing countries experience a much larger low-skilled services employment share and a smaller manufacturing employment share. The patterns before and after the peak of manufacturing are quite similar: The manufacturing employment share changes little and the low-skilled services employment share substantially expands.

Figure 6: Structural Transformation in Flat-Manufacturing Economies

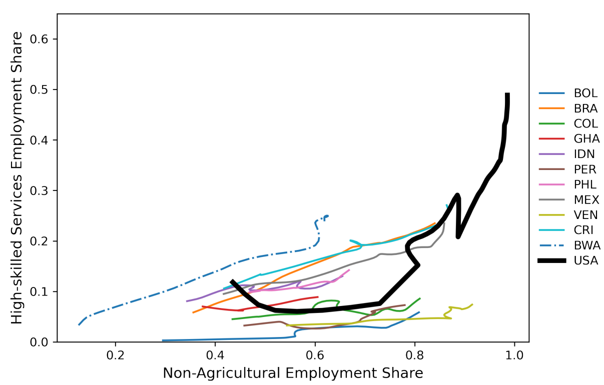
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



Notes: The solid black lines represent the evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the United States as a benchmark.

Figure 6 presents structural transformation patterns across the flat-manufacturing countries. We can observe that the flat-manufacturing countries exhibit flatter and lower-level profiles of the manufacturing employment share compared to the United States. The low-skilled services employment share is strikingly larger and expands at a steeper rate compared to the United States. The high-skilled services employment share remains insignificant throughout the sample period for most countries in the group.

3.3 Heterogeneous Patterns Across Recent Developing Economies

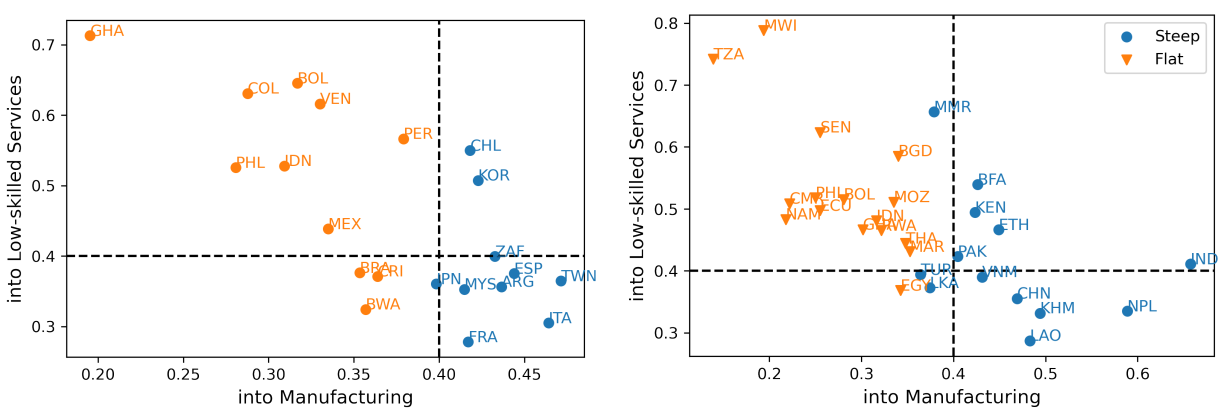
A natural question raised is whether a region or period is associated with the pattern of steep or flat-manufacturing. Rodrik (2016) suggests that countries tend to attain a lower manufacturing peak after 1990s. He conjectures from this finding that change in global sources such as the rise of globalization or labor-saving technology are main reason behind this phenomenon. However, there are two major limitations with Rodrik (2016)'s analysis. First, his analysis employs the GGDC 10-Sector Database which consists a few number of post-1990s industrializers. Second, as previous studies (including Rodrik (2016) and Huneeus and Rogerson (2023)) focus on the peak as the key feature of manufacturing hump-shaped patterns, their analysis is restricted to include only countries which have attained the manufacturing peak.

This paper overcomes these two limitations by using data from a broad set of recent emerging countries and focusing on the evolution of the labor allocation into manufacturing and services. Using data from GGDC/UNU-WIDER Economic Transformation Database (ETD) (de Vries et al., 2021), I document the structural transformation patterns across the recent developing countries. Among the 51 countries in the sample, there are 29 countries that have observed significant industrialization (at least 10 years) during the sample period.

Figure 7: Percentage of Labor Reallocation from Agriculture into Manufacturing vs. into Low-skilled Services

(a) GGDC 10-Sector Database

(b) GGDC/UNU-WIDER Economic Transformation Database

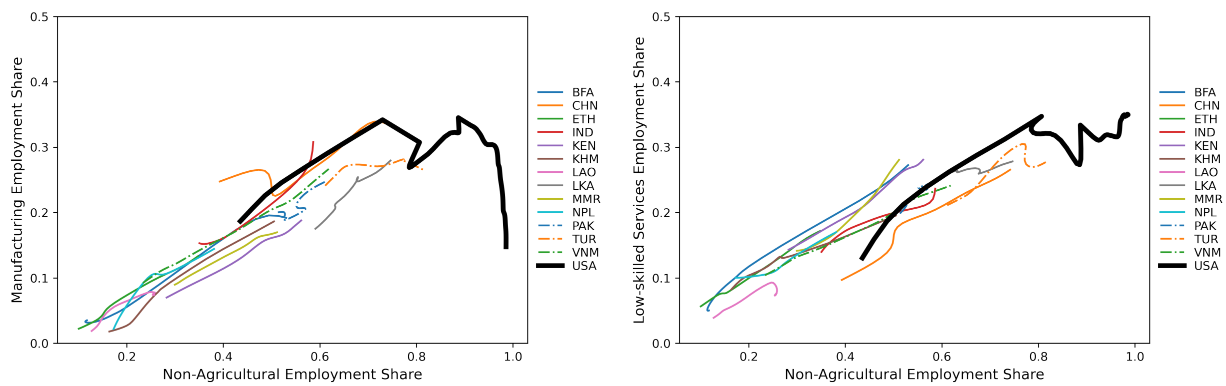


Notes: Figure (a) reports the variables for the earlier (post-1950s) developers from the GGDC 10-Sector Database. Figure (b) reports the variables for the later (post-1990s) developers from the Economic Transformation Database. The black dashed line presents the labor allocation process into manufacturing and low-skilled services in the United States during the industrialization: Out of 1% employment share leaving agriculture, around 0.4% employment share is reallocated towards manufacturing and low-skilled services.

Figure 7 shows the cross-country patterns of the labor reallocation out of agriculture into manufacturing and low-skilled services. Figure 7a and 7b plot the labor reallocation into manufacturing and low-skilled services of the earlier developers during 1950-2010 (from the GGDC 10-Sector Database) and the later developers during 1990-2018 (from the Economic Transformation Database) respectively. There are two major similar structural transformation patterns between the two samples. First, most countries in both samples reallocate employment out of agriculture mostly towards manufacturing and low-skilled services during early to middle stage of development. Economies that allocate less employment share into manufacturing (flat-manufacturing) tend to allocate more employment share into low-skilled services and vice versa. Second, different from Rodrik (2016)'s finding that post-1990 developers tend to attain a lower manufacturing peak and follow a flat-manufacturing pattern, figure 7b shows that 13 recent developers out of 29 allocate similar or even more labor into manufacturing compared to the United States during the industrialization phase. Moreover, both the steep and the flat-manufacturing patterns occur in all the three regions: Africa, Asia and Latin America. This evidence suggests that the heterogeneous paths of structural transformation are prevalent across countries and not subject to a specific time period or a geographical region.

Figure 8: Structural Transformation Patterns in Recent Steep-Manufacturing

(a) Manufacturing Employment Share　　(b) Low-skilled Services Employment Share

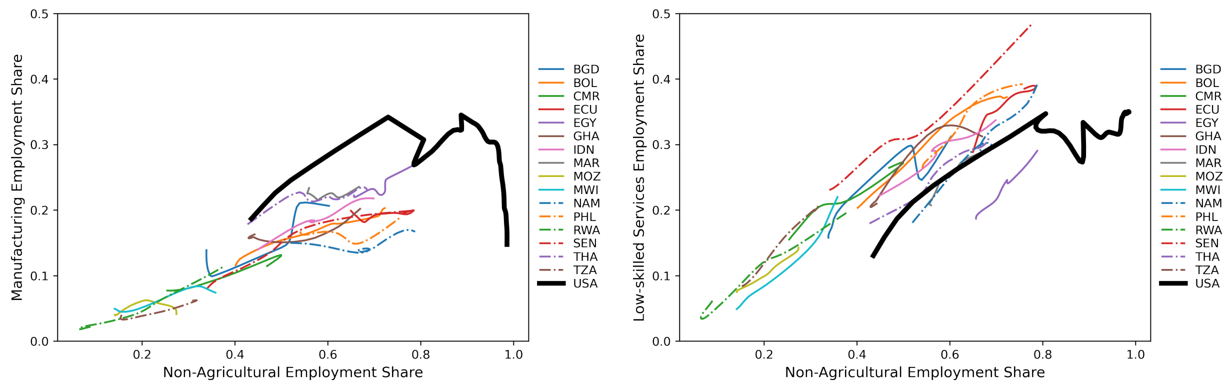


Notes: The solid black lines represent evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the United States as a benchmark.

Figure 8 and 9 illustrate the structural transformation patterns of the recent steep-manufacturing countries along with the countries exhibiting the flat-manufacturing pattern. In Figure 8a and 9a, while many recent emerging countries follow similar patterns to the United States with the steep evolution of the manufacturing employment share, many others follow the flat-manufacturing pattern with less labor reallocation towards manufacturing. Figure 8b and 9b show that compared to the United States and other recent steep-manufacturing countries, the recent flat-manufacturing countries also tend to allocate substantially more labor towards low-skilled services.

Figure 9: Structural Transformation Patterns in Recent Flat-Manufacturing

(a) Manufacturing Employment Share (b) Low-skilled Services Employment Share



Notes: The solid black lines represent evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the United States as a benchmark.

In summary, the structural transformation patterns are remarkably different across countries. While many countries follow a steep-manufacturing profile and a moderate rise of low-skilled services similar to the United States, many other countries exhibit a pattern of flat-manufacturing evolution and a substantial rise of low-skilled services. These two heterogeneous patterns of structural transformation are observed among both earlier (pre-1990s) and later (post-1990s) developers, suggesting that the heterogeneity in structural transformation cannot be simply explained by the timing of development as suggested by Rodrik (2016).

However, this finding does not contradict or refute the facts established by Rodrik (2016) and Sposi et al. (2021) that later developers (post-1990s) generally experience a lower peak in manufacturing employment share compared to earlier developers (pre-1990s) on average. Instead, it highlights the substantial heterogeneity in structural transformation patterns within both early and late developers. This suggests that the flat-manufacturing pattern is not exclusive to the post-1990s period, and similarly, the steep-manufacturing pattern is not confined to the pre-1990s group.

4 Model

In this section, I lay out a model of structural transformation as a framework to investigate the sources behind the heterogeneity in structural transformation across countries presented in the earlier section. In the model, sectoral labor productivities are the key driving forces behind labor reallocation across sectors. I also present the calibration strategy for the key parameters in the model and provide theoretical insights on potential sources driving the phenomenon of cross-country heterogeneity in structural transformation.

4.1 Model Description

I consider a standard benchmark model of structural transformation following Rogerson (2008) and Duarte and Restuccia (2010). In each period, four different types of goods are produced using a technology linear in labor: Agriculture (a), manufacturing (m), low-skilled services (ls) and high-skilled services (hs).

Production. Technology

$$Y_i = A_i L_i, \qquad i \in \{a, m, ls, hs\} \tag{1}$$

where Y_i is output, L_i is labor input and A_i is labor productivity in sector i.

Households. A representative household is endowed with 1 unit of time and have preferences over four consumption goods. Following Duarte and Restuccia (2010), the model assumes a Stone-Geary preference over agricultural (c_a) and non-agricultural consumption (c_n):

$$u(c_a, c_n) = \alpha log(c_a - \bar{a}) + (1-\alpha) log(c_n)$$

Following Comin et al. (2021), preferences over manufacturing, low-skilled services and high-skilled services follow non-homothetic CES preferences implicitly defined by the following constraint

$$\sum_{i \in \{m, ls, hs\}} \left[\omega_i^{\frac{1}{\sigma}} \left(\frac{c_i}{c_n^{\epsilon_i}} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} = 1, \quad \text{with} \quad \sum_{i \in \{m, ls, hs\}} \omega_i = 1 \tag{2}$$

The literature emphasizes on two forces behind structural transformation between manufacturing and services: income effect and substitution effect. However, similar to Huneeus and Rogerson (2023), I also find a limited role of income effect in allocating labor between manufacturing and services sectors during early to middle stage of development across countries.

Market structure. Firms are competitive in output and labor markets. Given market prices $\{p_i\}$ and wage w, a representative firm chooses labor input to maximize profit and the representative household chooses consumption allocations to maximize utility subject to the budget constraint. Population size is normalized to 1.

Competitive Equilibrium. The equilibrium consists of a set of allocations $\{c_a, c_m, c_{ls}, c_{hs}\}$, $\{L_a, L_m, L_{ls}, L_{hs}\}$ and a set of prices $\{p_a, p_m, p_{ls}, p_{hs}\}$ (wage w is normalized to 1) such that

1. Given a set of prices $\{p_i\}$, $\{c_i\}$ solves the representative household's problem

$$\underset{\{c_i\}_{i=a,m,ls,hs}}{max} \quad u(c_a, c_m, c_{ls}, c_{hs}) \quad \text{s.t.} \quad \sum_{i=a,m,ls,hs} p_i c_i = 1 \tag{3}$$

2. Given a set of prices $\{p_i\}$, $\{L_i\}$ solves the representative firm's problem

$$\underset{L_i}{max} \quad p_i A_i L_i - L_i \tag{4}$$

3. Goods markets clear

$$c_i = Y_i, \quad i \in \{a, m, ls, hs\} \tag{5}$$

4. Labor market clears

$$L_a + L_m + L_{ls} + L_{hs} = 1 \tag{6}$$

Given the linear production technology, from the representative firm's problem, the sectoral prices can be derived as the inverse of the sectoral labor productivity:

$$p_i = \frac{1}{A_i}, \quad i \in \{a, m, ls, hs\} \tag{7}$$

Combining with the goods market clearing conditions, the expenditure share and the employment share are equal for each sector

$$p_i c_i = p_i Y_i = L_i, \quad i \in \{a, m, ls, hs\} \tag{8}$$

The representative household's problem and the market clearing conditions will then determine the sectoral expenditure and the employment shares.

Given prices $\{P_a, P_n\}$, the household first solves for consumption of agricultural (c_a) and non-agricultural goods (c_n) to maximize utility subject to the budget constraint

$$\underset{c_a, c_n}{max} \quad \alpha log(c_a - \bar{a}) + (1-\alpha) log(c_n) \quad \text{s.t.} \quad P_a c_a + P_n c_n = 1$$

The optimal consumption for agricultural good can be derived as $c_a = \frac{\alpha}{P_a} + (1-\alpha)\bar{a}$. Combining with market clearing condition for agricultural good, the agricultural employment share can be derived as

$$L_a = \alpha + (1-\alpha)\frac{\bar{a}}{A_a}$$

The remaining income ($E = 1 - P_a c_a$) is allocated towards c_m, c_{ls} and c_{hs}. The household determine the optimal expenditure for each sector $i = m, ls, hs$ by solving

$$\underset{c_m,c_{ls},c_{hs}}{min} \sum_{i\in\{m,ls,hs\}} P_i c_i \quad \text{s.t.} \quad \sum_{i\in\{m,ls,hs\}} \left[\omega_i^{\frac{1}{\sigma}} \left(\frac{c_i}{c_n^{\epsilon_i}}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = 1$$

The problem yields the following first order conditions (FOCs):

$$\frac{P_i c_i}{P_j c_j} = \left(\frac{\omega_i}{\omega_j}\right)^{\frac{1}{\sigma}} \frac{\left(\frac{c_i}{c_n^{\epsilon_i}}\right)^{\frac{\sigma-1}{\sigma}}}{\left(\frac{c_j}{c_n^{\epsilon_j}}\right)^{\frac{\sigma-1}{\sigma}}} \quad \forall i, j \in \{m, ls, hs\} \tag{9}$$

As a result,

$$\frac{P_i c_i}{P_m c_m + P_{ls} c_{ls} + P_{hs} c_{hs}} = \frac{\omega_i^{\frac{1}{\sigma}} \left(\frac{c_i}{c_n^{\epsilon_i}}\right)^{\frac{\sigma-1}{\sigma}}}{\sum_j \omega_j^{\frac{1}{\sigma}} \left(\frac{c_j}{c_n^{\epsilon_j}}\right)^{\frac{\sigma-1}{\sigma}}}$$

Given that $\sum_j \omega_j^{\frac{1}{\sigma}} \left(\frac{c_j}{c_n^{\epsilon_j}}\right)^{\frac{\sigma-1}{\sigma}} = 1$ by the constraint defining the preference,

$$\Rightarrow \frac{P_i c_i}{1 - P_a c_a} = \frac{\omega_i^{\frac{1}{\sigma}} \left(\frac{c_i}{c_n^{\epsilon_i}}\right)^{\frac{\sigma-1}{\sigma}}}{1}$$

From market clearing condition for sector i ($c_i = A_i L_i$) and firm's FOCs ($P_i A_i = 1$), we have:

$$\frac{L_i}{1 - L_a} = \omega_i^{\frac{1}{\sigma}} \left(\frac{A_i L_i}{c_n^{\epsilon_i}}\right)^{\frac{\sigma-1}{\sigma}}$$

Rearranging the terms yields the following expression for the employment share in each sector $i \in \{m, ls, hs\}$,

$$\frac{L_i}{(1 - L_a)^{\sigma}} = \omega_i A_i^{\sigma-1} c_n^{\epsilon_i(1-\sigma)}$$

Combining with the nonhomothetic CES preference constraint, we can solve for L_m, L_{ls}, L_{hs}, and c_n as the solution to a system of 4 equations:

$$\frac{L_m}{(1-L_a)^\sigma} = \omega_m A_m^{\sigma-1} c_n^{\epsilon_m(1-\sigma)} \tag{10}$$

$$\frac{L_{ls}}{(1-L_a)^\sigma} = \omega_{ls} A_{ls}^{\sigma-1} c_n^{\epsilon_{ls}(1-\sigma)} \tag{11}$$

$$\frac{L_{hs}}{(1-L_a)^\sigma} = \omega_{hs} A_{hs}^{\sigma-1} c_n^{\epsilon_{hs}(1-\sigma)} \tag{12}$$

$$\sum_{i\in\{m,ls,hs\}} \left[\omega_i^{\frac{1}{\sigma}} \left(\frac{A_i L_i}{c_n^{\epsilon_i}} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} = 1 \tag{13}$$

4.2 Benchmark Calibration to the United States

I calibrate the model parameters to capture the evolution of the sectoral employment shares in the United States from 1880 to 1950, covering the early to middle stages of development. The calibration strategy comprises two steps. First, I calibrate sectoral productivity profiles $\{A_{at}, A_{mt}, A_{lst}, A_{hst}\}$. Second, given the sectoral productivity profiles, I calibrate the household preference parameters $(\alpha, \bar{a}, \sigma, \epsilon_m, \epsilon_{ls}, \epsilon_{hs}, \varphi_m, \varphi_{ls}, \varphi_{hs})$ to align with the observed evolution of employment shares in the United States.

Following the standard practice in literature, I focus on the case assuming constant technological progress in each of the four sectors

$$A_{it} = A_{i0} e^{g_i t}, \quad i \in \{a, m, ls, hs\}$$

Each sectoral productivity profile $\{A_{it}\}$ is characterized by sectoral productivity growth rate (g_i) and initial labor productivity level (A_{i0}). Due to the lack of data on the sectoral productivity in the United States for the period 1880-1950, I follow Huneeus and Rogerson (2023) to assume the agricultural productivity growth (g_a) to be 2.39% to match the observed trend in the agricultural employment share. Other sectoral productivity growth rates (g_m, g_{ls}, g_{hs}) during the period 1880-1950 are assumed to be the growth rates between 1950 and 1970. All sectoral productivity levels in the initial period (A_{i0}) are normalized to 1.

Given the sectoral productivity profiles, I will calibrate the set of parameters for household preference. The model predicts agricultural employment share converging to α, set at 0.02 to align with the data in most developed economies. Following Comin et al. (2021), ϵ_m is normalized to 1, as the income effect is driven only by the relative differences in income elasticities across sectors, rather than their absolute magnitudes. With 7 parameters to calibrate ($\bar{a}$, σ, ϵ_{ls}, ϵ_{hs}, φ_m, $\varphi_{ls}, \varphi_{hs}$), I match sectoral employment shares in the United States. Table 1 presents the calibrated value for each parameter.

Table 1: Benchmark Calibration

Parameters	α	$\bar{a}$	σ	ϵ_m	ϵ_{ls}	ϵ_{hs}	φ_m	φ_{ls}	φ_{hs}
Value	0.02	0.49	0.30	1.00	1.00	1.20	0.47	0.42	0.11

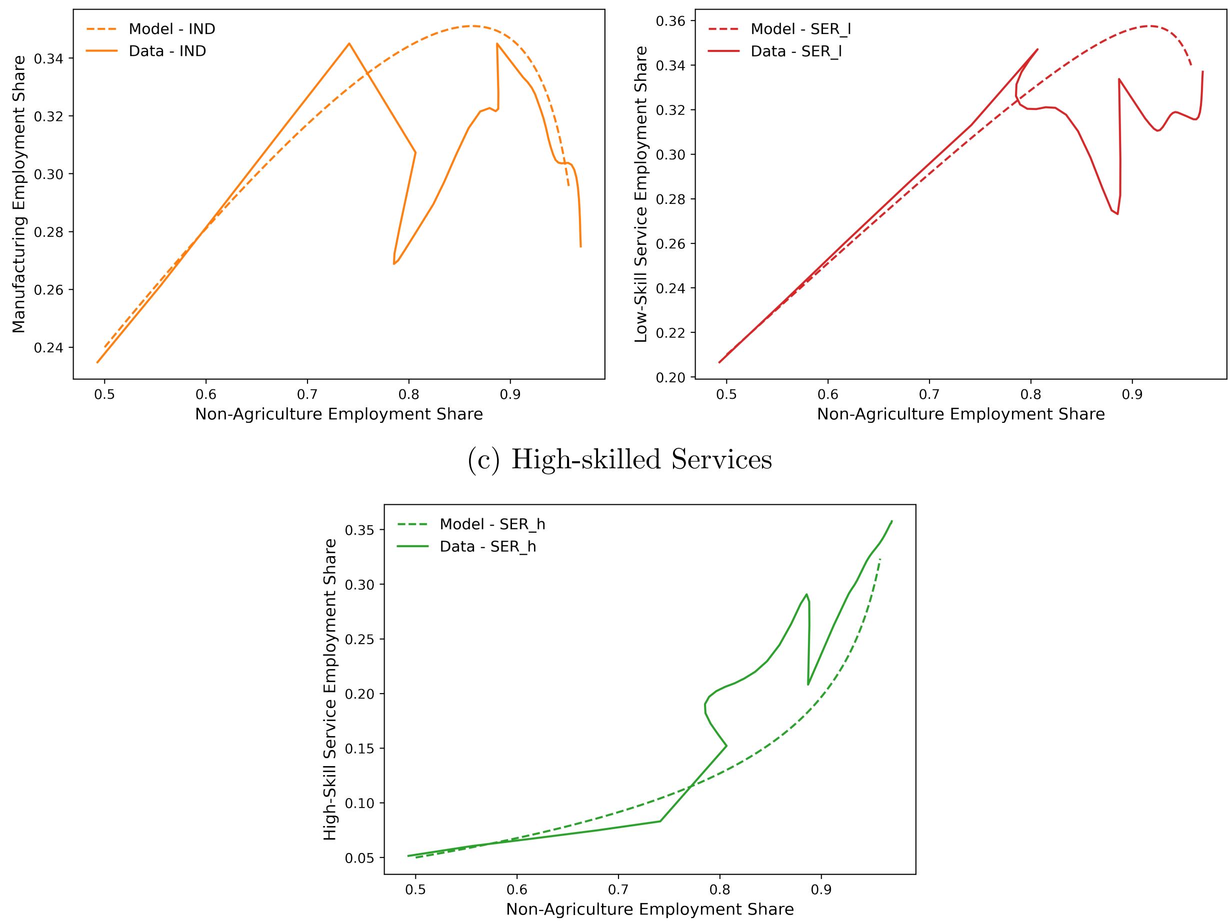
As discussed earlier, the evolution of sectoral employment shares in the United States exhibits disruptive breaks during the Great Depression and World War II periods. My calibration abstracts from these breaks and implicitly reflects the evolution that would have happened if the Great Depression and World War II had not happened. Figure 10 shows the fit of the calibrated model to the data in the United States. The model can generate the structural transformation patterns close to the observed data. The model can generate the steep hump-shaped profile of manufacturing employment share.

As previously discussed, the evolution of sectoral employment shares in the United States experiences disruptive breaks during the Great Depression and World War II periods. My calibration abstracts from these breaks and implicitly reflects the evolution that would have occurred if the Great Depression and World War II had not happened. Figure 10 illustrates the fit of the calibrated model to the data in the United States. The model generates the structural transformation patterns close to the observed data, including the steep hump-shaped profile of manufacturing employment share, the emergence of low-skilled services during the early and middle stages of development, and the subsequent rise of high-skilled services in the later stages of development.

The calibrated values are within the reasonable range of previous studies. Parameter $\bar{a}$ is found to be 0.49, consistent with Huneeus and Rogerson (2023), suggesting a strong income effect for agricultural consumption. The calibrated value for the elasticity of subsitution σ is quite close to previous studies such as estimated value of 0.3 using micro data in Comin et al. (2021) and calibrated value of 0.35 in Huneeus and Rogerson (2023). The values for income elasticity ϵ_{ls} and ϵ_{hs} also suggests limited role of income effect during early and middle stages of development, similar to findings in Huneeus and Rogerson (2023). Most income effect for broad services sector is driven by the high-skilled services.

Figure 10: Structural Transformation in the United States: Model vs. Data

(a) Manufacturing (b) Low-skilled Services (c) High-skilled Services



Notes: The figure plots the sectoral employment shares against non-agricultural employment share of the United States. The dashed lines represent the model and the solid lines represent the data.

4.3 Sources of Structural Transformation

The theoretical model proposes that deviations in sectoral productivity profiles drive heterogeneity in structural transformation patterns. These deviations stem from sectoral productivity growth rates (dynamic factors) and initial sectoral productivity levels (static factors). Previous research (Huneeus and Rogerson, 2023) highlights the significant role of agricultural productivity growth in explaining variations in the manufacturing peak compared to productivity growth in manufacturing and services sectors.

This paper introduces and explores initial sectoral productivity levels as a novel factor shaping observed patterns (see Section 3). The model suggests that two economies with similar sectoral productivity growth rates may exhibit different relative productivity profiles if their initial relative productivity levels in non-agricultural sectors differ. Consider a simplified scenario involving the United States as a benchmark economy and another economy c. Assuming both countries share identical productivity growth rates in all sectors ($g_i^c = g_i^{US} = g_i \quad \forall i \in \{a, m, ls, hs\}$) and the same initial agricultural productivity level ($A_{a,0}^c = A_{a,0}^{US}$), their sole distinction lies in the initial relative sectoral productivity levels among non-agricultural sectors ($\frac{A_{i,0}^c}{A_{m,0}^c} \neq \frac{A_{i,0}^{US}}{A_{m,0}^{US}} \quad \forall i \in \{ls, hs\}$).

As sectoral productivity grows uniformly in both countries, the relative productivity levels among non-agricultural sectors differ between country c and the United States at any given period t ($\frac{A_{i,t}^c}{A_{m,t}^c} \neq \frac{A_{i,t}^{US}}{A_{m,t}^{US}} \quad \forall i \in \{ls, hs\}$), and these differences persist from the initial disparities:

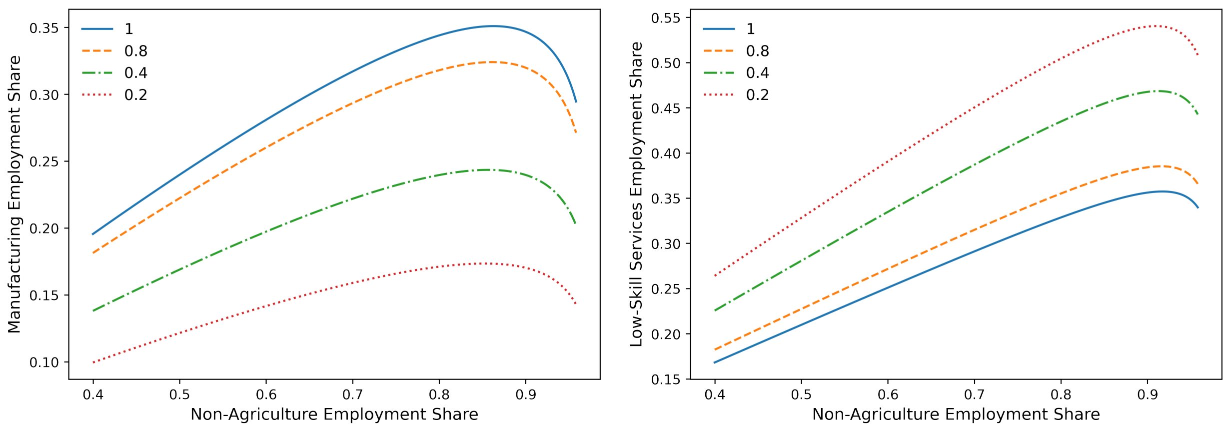
$$\frac{A_{i,t}^c/A_{m,t}^c}{A_{i,t}^{US}/A_{m,t}^{US}} = \frac{A_{i,0}^c/A_{m,0}^c}{A_{i,0}^{US}/A_{m,0}^{US}} \frac{e^{(g_i-g_m)t}}{e^{(g_i-g_m)t}} = \frac{A_{i,0}^c/A_{m,0}^c}{A_{i,0}^{US}/A_{m,0}^{US}} \quad \forall i \in \{ls, hs\}$$

The disparity in initial relative productivity levels reflects a persistent gap in relative sectoral productivity levels between the two economies over their developmental trajectories. This gap may arise from country-specific static factors such as past growth rates, institutional factors, distortions, and human capital endowments. Consequently, this disparity in initial relative productivity levels influences patterns of labor allocation, particularly in flat-manufacturing economies where lower manufacturing employment shares and higher low-skilled services employment shares are observed. Thus, a flat-manufacturing economy is expected to exhibit a lower relative labor productivity of low-skilled services to manufacturing compared to the United States: $\frac{A_{ls,0}^c}{A_{m,0}^c} < \frac{A_{ls,0}^{US}}{A_{m,0}^{US}}$.

To illustrate the quantitative impact of the initial relative productivity channel, I consider four counterfactual economies with labor productivity growth rates similar to the United States but with lower initial relative labor productivity levels of low-skilled services to manufacturing. To isolate the substitution effect channel and abstract from the income effect channel, the counterfactuals adjust the initial productivity levels of manufacturing and low-skilled services to maintain aggregate productivity at the same level as the benchmark economy.

Figure 11: Initial Relative Productivity Levels and Structural Change Patterns

(a) Manufacturing (b) Low-skilled Services



Notes: The solid blue lines represent the sectoral employment shares in the United States as a benchmark. The dashed lines represent four counterfactual economies which only differ from the benchmark economy in the initial productivity levels of low-skilled services relative to manufacturing ($\frac{A_{ls,0}}{A_{m,0}} = 0.8, 0.4, 0.2$) with the same aggregate producitvity level.

Figure 11 depicts the evolution of sectoral employment shares in these four counterfactual economies, where the initial relative labor productivity levels of low-skilled services to manufacturing are set at 0.8, 0.4, and 0.2 relative to the benchmark economy (the United States). The solid blue lines represent the structural transformation pattern in the United States, while the dashed lines exhibit the patterns in the four counterfactual economies. This departure, where the initial relative productivity levels are the only source of variation, generates similar patterns to those observed in flat-manufacturing economies: flatter evolutions of manufacturing employment shares and steeper rises in the employment share of low-skill services. The counterfactuals suggest that a lower initial productivity of low-skilled services relative to manufacturing can qualitatively characterize the deviations in structural transformation patterns of flat-manufacturing economies from the United States.

5 Cross-country Analysis

Based on the model calibrated to the United States as a benchmark economy, this section extends the analysis to study forces driving the heterogeneity in structural transformation patterns across countries. The section first starts with the calibration of sectoral productivity growth and initial levels across countries. I next present a set of counterfactuals showing the decomposition of the sources behind the heterogeneous paths of structural transformation.

5.1 Cross-country Calibration

For each country c in each year t, using the model, I calibrate the four sectoral productivity levels $(A^c_{a,t}, A^c_{m,t}, A^c_{ls,t}, A^c_{hs,t})$ targeting 4 moments: agricultural employment share $(L^c_{a,t})$, manufacturing employment share $(L^c_{m,t})$, low-skilled services employment share $(L^c_{ls,t})$ provided by the GDDC 10-Sector Database and aggregate labor productivity level (PPP) relative to the United States (A^c_t) provided by the Penn World Table (PWT) 10.0. The calibration strategy follows Duarte and Restuccia (2010) and Huneeus and Rogerson (2023). For each country c and sector $i \in \{a, m, ls, hs\}$, I then estimate the implied annualized sectoral productivity growth rates (g^c_i) by regressing the logarithm of $(A^c_{i,t})$ on t.

For each country c and sector i, to remove noises and capture the trend, I compute the constant-growth sectoral productivity levels $(\tilde{A}^c_{i,t})$ based on the calibrated productivity levels in initial periods $(A^c_{i,0})$ and the calibrated growth rates (g^c_i) as follows:

$$\tilde{A}^c_{i,t} = A^c_{i,0}(1 + g^c_i)^t, \quad i \in \{a, m, ls, hs\}.$$

The model-implied sectoral employment shares $(\tilde{L}^c_{a,t}, \tilde{L}^c_{m,t}, \tilde{L}^c_{ls,t}, \tilde{L}^c_{hs,t})$ assuming constant sectoral productivity growth are then computed based on $(\tilde{A}^c_{a,t}, \tilde{A}^c_{m,t}, \tilde{A}^c_{ls,t}, \tilde{A}^c_{hs,t})$. The calibration is conducted for each country in the sample period 1950-2010.

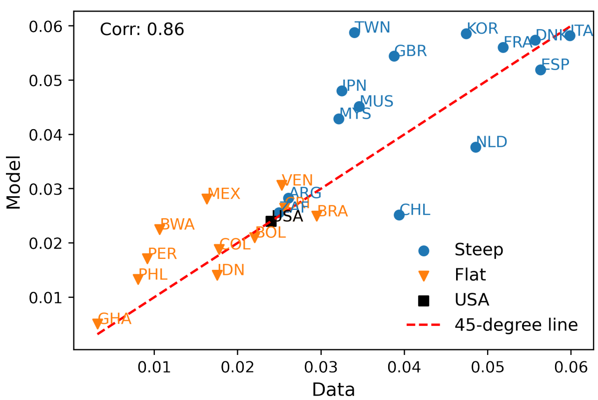
As model validation check, I also estimate annualized sectoral productivity growth rates for each country in the sample. For each country c, sectoral productivity growth in the data is estimated by regressing the logarithm of real value-added per worker on time using the data provided by the GDDC 10-Sector Database.

The calibrated productivity growth rates (g^c_i) for each sector are plotted against the data in Figure 12. The model generates the sectoral productivity growth rates that are quite close to the data for most countries. Specifically, the correlation between the model and the data is 0.85 for agricultural sector, 0.91 for manufacturing sector, and 0.75 for both low-skilled services sector and high-skilled services sector. The fit is considered quite good given the simplicity of the model.

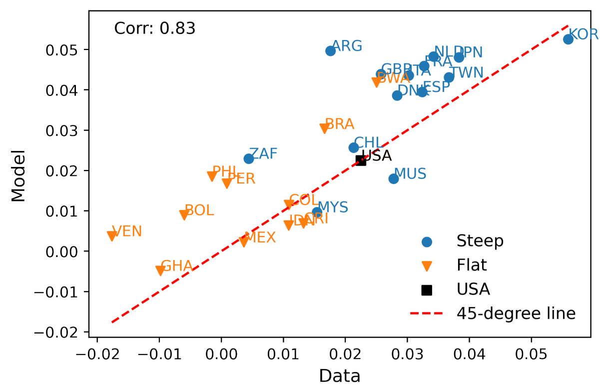
Variations in sectoral productivity growth rates are apparent across countries. Both in the model and observed data, the steep-manufacturing countries exhibit higher productivity growth in agriculture, manufacturing, and low-skilled services sectors compared to the flat-manufacturing countries. On average, the steep-manufacturing countries experience model-implied annualized growth rates of 4.6% in agriculture, 3.8% in manufacturing, and 2.2% in low-skilled services. In contrast, the flat-manufacturing countries observe lower growth rates, averaging 2.0% in agriculture, 1.3% in manufacturing, and 0.0% in low-skilled services. There are no discernible differences in high-skilled productivity growth rates between the flat- and the steep-manufacturing countries.

Figure 12: Annualized Sectoral Productivity Growth Rate (g_i^c): Model vs. Data

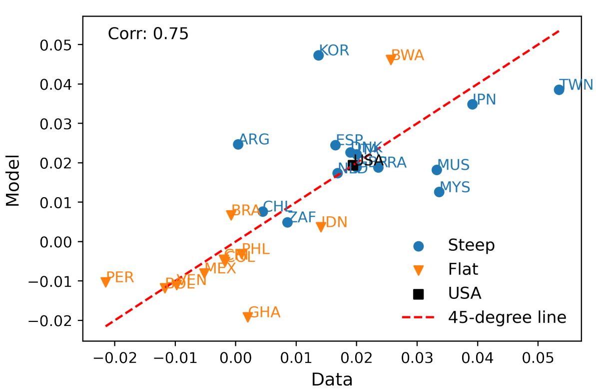
(a) Agriculture



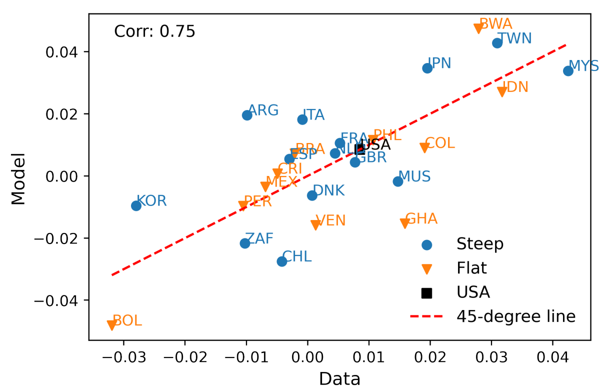
(b) Manufacturing



(c) Low-skilled Services



(d) High-skilled Services

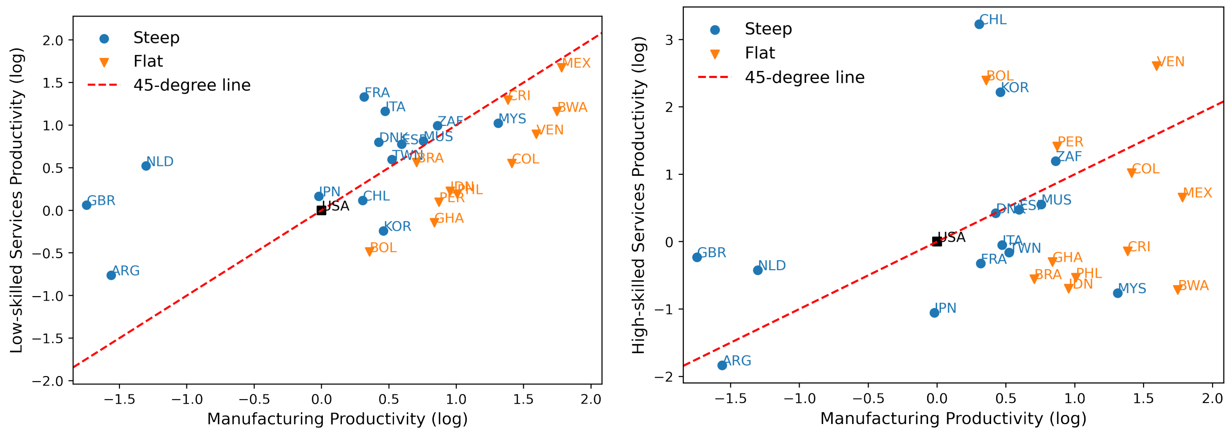


Notes: The plot reports the annualized sectoral productivity growth rate implied by the model and the data. The red dashed line represents the 45-degree line on which the growth rate implied by the model perfectly fits the growth rate in the data.

Figure 13 reported calibrated values for productivity levels in low-skilled services ($\tilde{A}^c_{ls,t}$) and high-skilled services ($\tilde{A}^c_{hs,t}$) relative to manufacturing ($\tilde{A}^c_{m,t}$) at the same level of development of 50% employment share in agriculture. Steep-manufacturing countries tend to show the pattern of high productivity levels of low-skilled services relative to manufacturing (relative to the United States). On average, at 50% agricultural employment share, steep manufacturing countries have low-skilled services productivity levels relative to manufacturing at 2.1 times the United States, whereas flat-manufacturing countries have low-skilled services productivity levels relative to manufacturing at 0.6 times the United States.

Figure 13: Sectoral Productivity Levels ($\tilde{A}^c_{i,t}$) at 50% Agricultural Employment Share ($\tilde{L}^c_{a,t}$)

(a) Low-skilled Services vs. Manufacturing (b) High-skilled Services vs. Manufacturing



Notes: The plot reports the productivity levels implied by the model for low-skilled services, high-skilled services and manufacturing for each country at the same level of 50% agricultural employment share. The red dashed line represents the 45-degree line on which relative productivity of the sector to manufacturing is the same as the United States.

For high-skilled services productivity levels, there is no clear pattern between steep- and flat-manufacturing countries. There is a lot of heterogeneity across countries within group. On average, at 50% agricultural employment share, steep manufacturing countries have high-skilled services productivity levels relative to manufacturing at 1.5 times the United States, whereas flat-manufacturing countries have high-skilled services productivity levels relative to manufacturing at 1.3 times the United States.

5.2 Counterfactual Analysis

I perform counterfactual analysis to decompose the quantitative importance of the initial sectoral productivity levels (static factors) and the sectoral productivity growth rates (dynamic factors) in generating the heterogeneous patterns across countries. As discussed in section 4, the static and the dynamic factors are the two forces driving the heterogeneous sectoral productivity profiles across economies. The counterfactuals are conducted by setting the growth rates of labor productivity in all sectors to the rates of the United States, leaving the initial sectoral productivity levels the same as calibrated values. These counterfactuals illustrate the importance of the initial sectoral productivity levels for the cross-country patterns in the sectoral labor allocation. The counterfactual results indicate that differences in the initial sectoral productivity levels are found to be the main drivers of the heterogeneity in structural transformation patterns between the steep- and the flat-manufacturing countries.

Illustrating Example of Colombia

I first present the findings of the counterfactual exercise through an illustration of Colombia (COL). Figure 14 exhibits the evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the counterfactuals together with the pattern in Colombia.

Figure 14a plots the United States' sectoral employment shares from the model (which is close to the shares in the United States data presented earlier in Figure 10) and Colombia's sectoral employment shares from the data. The manufacturing employment share in the United States experience a steep hump shape with significantly higher values than Colombia during the industrialization phase. Low-skilled services employment share is substantially higher in Colombia compared to the United States over the whole sample period. The economic structures between the United States and Colombia are substantially different. At 70% non-agricultural employment share, while the United States has approximately 32% employment share in manufacturing and 29% employment share in low-skilled services, Colombia has approximately 20% employment share in manufacturing and 44% employment share in low-skilled services.

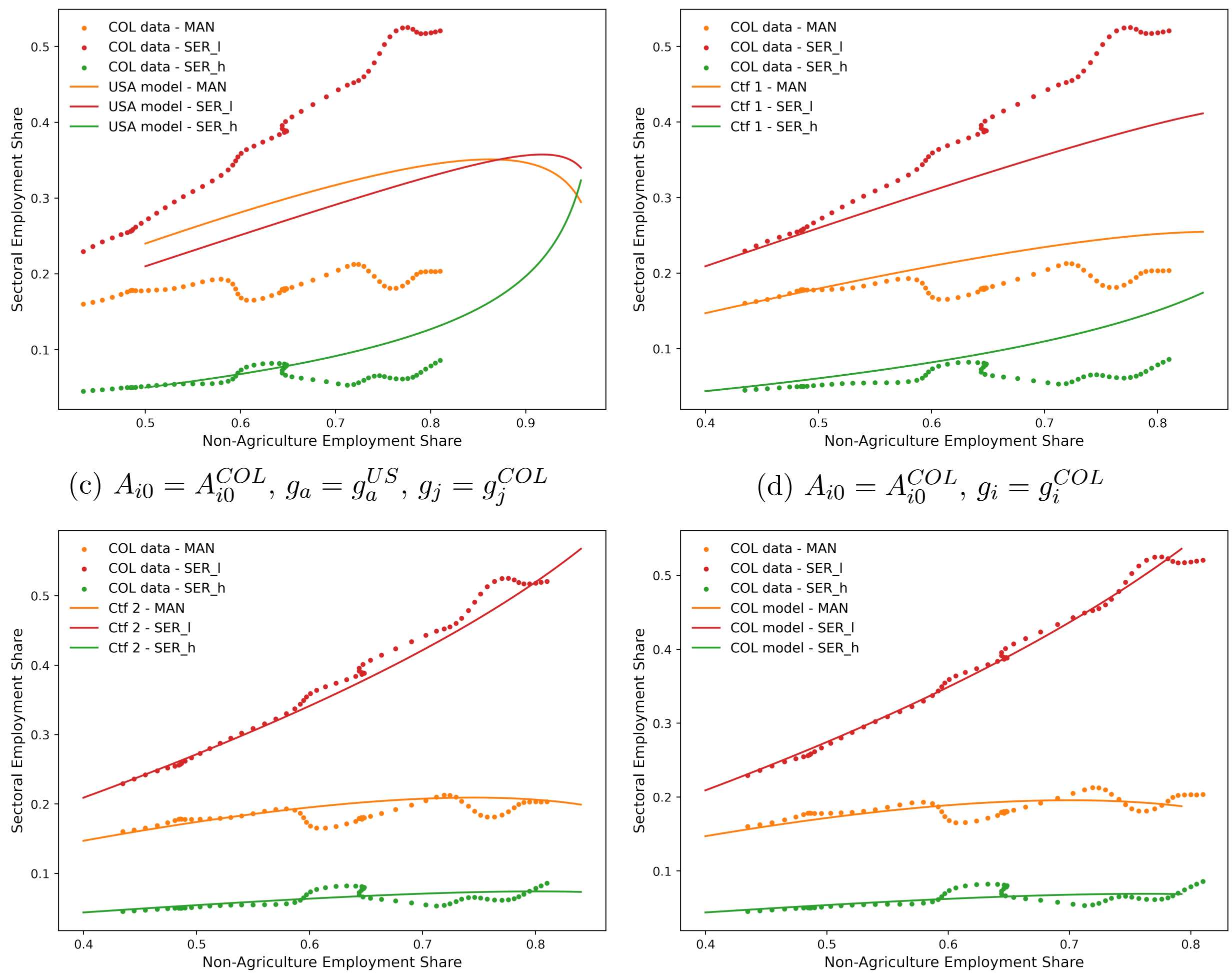
Figure 14b exhibits the sectoral employment shares in Colombia data and the first counterfactual using Colombia's initial sectoral labor productivity levels together with the United States's productivity growth rates in agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactual can generate structural transformation patterns closer to the data with a steeper rise in low-skilled services and a flatter hump shape of manufacturing. The counterfactual shows that differences in structural transformation patterns between Colombia and the United States largely remain after shutting down all the differences in sectoral productivity growth rates between the two countries. This result suggests that the initial relative productivity levels are quantitatively important to account for the observed heterogeneous structural transformation patterns between Colombia and the United States. The remaining gaps in the structural transformation patterns between this counterfactual and the data are attributed to the dynamic factors (the sectoral productivity growth rates).

Figure 14d shows that incorporating both the sectoral initial productivity levels and the sectoral productivity growth rates of Colombia generate the structural transformation patterns very close to the data. Figure 14c shows the sectoral employment shares by the counterfactual using Colombia's initial sectoral labor productivity with the United States's agricultural productivity growth and Colombia's productivity growth rates in the other three sectors. The sectoral employment shares generated by this counterfactual are also close to the data, suggesting a limited explanatory power of productivity growth in agriculture.

Figure 14: Sectoral Employment Shares: Counterfactual vs. Colombia data

(a) $A_{i0} = A_{i0}^{US}$, $g_i = g_i^{US}$ (b) $A_{i0} = A_{i0}^{COL}$, $g_i = g_i^{US}$

(c) $A_{i0} = A_{i0}^{COL}$, $g_a = g_a^{US}$, $g_j = g_j^{COL}$ (d) $A_{i0} = A_{i0}^{COL}$, $g_i = g_i^{COL}$



Notes: Each plot presents sectoral employment share of the data in Colombia along with the benchmark model or the counterfactuals. Figure (a) shows the sectoral employment shares in the benchmark model of the United States. Figure (b) shows the sectoral employment shares in the counterfactual assuming Colombia's initial sectoral relative productivity levels and the United States' sectoral productivity growth rates. Figure (c) shows the sectoral employment shares in the counterfactual assuming Colombia's initial sectoral relative productivity levels, Colombia's sectoral productivity growth rates in non-agricultural sectors and the United States' agricultural productivity growth rates. Figure (d) shows the sectoral employment shares in the counterfactual using the initial sectoral productivity levels and the sectoral productivity growth rates in Colombia.

At 75% non-agricultural employment share, the initial relative labor productivity contributes around 68% and 55% to the observed differences in manufacturing and low-skilled services employment shares between the United States and Colombia. The sectoral productivity growth rates explain around 26% and 45% respectively to the observed difference in the manufacturing and the low-skilled services employment share. Among the four sectors, the agricultural productivity growth contributes only about 10% to both the observed differences in the manufacturing and the low-skilled services employment shares.

Cross-country Counterfactual Results

The counterfactual analysis unfolds as follows: For each country c, I first compute the counterfactual sectoral productivity levels ($\hat{A}^c_{i,t}$) by assuming the country's initial sectoral productivity levels ($A^c_{i,0}$) and the United States' sectoral productivity growth rates (g_i^{US}) using the following formula:

$$\hat{A}^c_{i,t} = A^c_{i,0}(1 + g_i^{US})^t, \quad i \in \{a, m, ls, hs\}.$$

Subsequently, I compute the counterfactual sectoral employment shares ($\hat{L}^c_{a,t}$, $\hat{L}^c_{m,t}$, $\hat{L}^c_{ls,t}$, $\hat{L}^c_{hs,t}$) based on these counterfactual productivities ($\hat{A}^c_{a,t}$, $\hat{A}^c_{m,t}$, $\hat{A}^c_{ls,t}$, $\hat{A}^c_{hs,t}$).

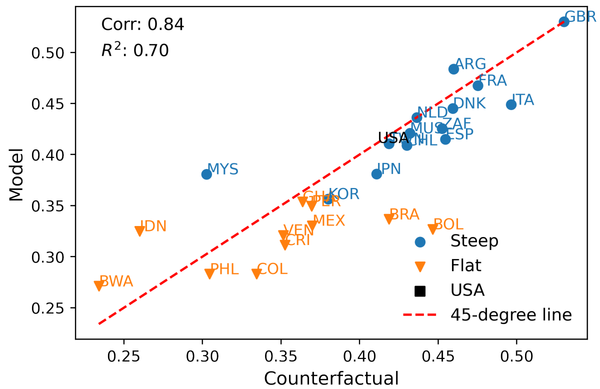
As described in section 3, the structural transformation patterns in early to middle stages of development are characterized by the reallocation of employment from agriculture into manufacturing, low-skilled services and high-skilled services. The heterogeneity in structural transformation patterns across countries is reflected in the differences in the slopes of employment shares in manufacturing, low-skilled services and high-skilled services with respect to non-agricultural employment share.

Based on the model-implied sectoral employment share ($\tilde{L}^c_{i,t}$) and countefactual sectoral employment share ($\hat{L}^c_{i,t}$) for each country c, I then calculate the slope of employment share in manufacturing, low-skilled services, and high-skilled services with respect to non-agricultural employment share in both the model and the counterfactual. Given that the evolution of manufacturing is hump-shaped in steep-manufacturing countries, I compute the slope of employment share in sector i with respect to non-agricultural employment share for the industrialization period, defined as the period up to the time T^* at which manufacturing employment share reaches its maximum $L^c_{m,T^*} = \max_t(L^c_{m,t})$.

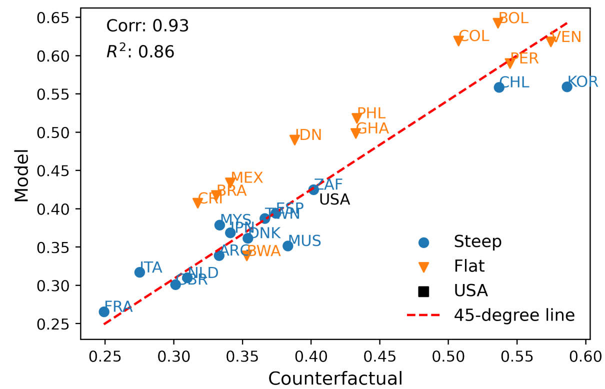
Figure 15 illustrates the slope of employment shares in manufacturing, low-skilled services, and high-skilled services concerning non-agricultural employment share in both the model and the counterfactual. In the model, the variability in structural transformation patterns arises from differences in both the initial sectoral productivity levels and the sectoral productivity growth rates. Conversely, in the counterfactual, the sole source of variation in structural transformation patterns is the initial sectoral productivity levels. Notably, differences in initial sectoral productivities account for the majority of the variation in structural transformation patterns across countries. Specifically, variations in initial sectoral productivity levels explain 70% of the variation in manufacturing slopes, 86% of the variation in low-skilled services slopes, and 68% of the variation in high-skilled services slopes. The remaining variance in slopes is attributed to the variations in sectoral productivity growth rates. On average, the static factor contributes to approximately 80% of the variance in slopes across countries, while the dynamic factor accounts for the remaining 30% of the variance in slopes across countries.

Figure 15: Slope of Sectoral Employment Share against Non-Agricultural Employment Share: Counterfactual (assuming United States growth) vs. Model

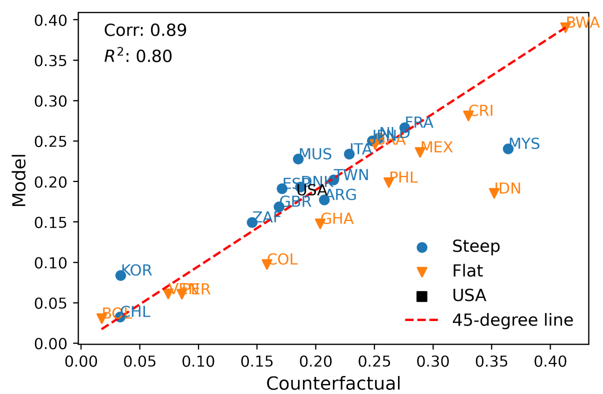
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

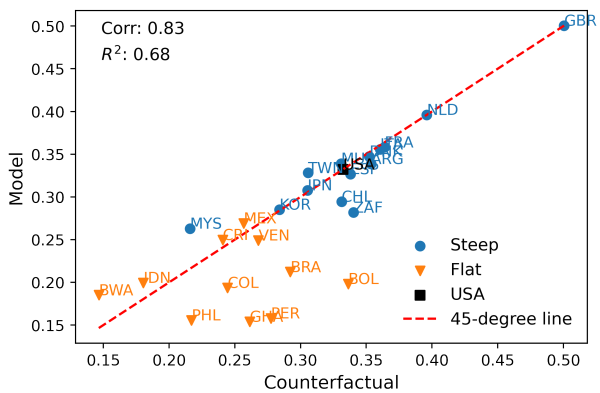


Notes: The counterfactual assumes each country's initial sectoral productivity level and the United States' sectoral productivity growth rates. Each plot reports the model-implied and counerfactual-implied slopes of the employment share in manufacturing, low-skilled services and high-skilled services with respect to non-agricultural employment share. The red dashed line represents the 45-degree line on which the counterfactual perfectly fits the data.

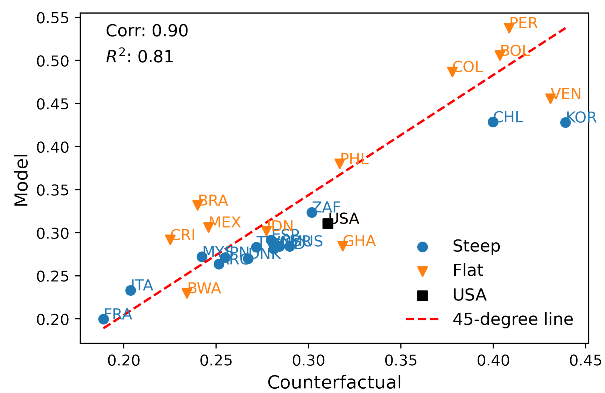
As a robustness check, I present results on sectoral employment shares in manufacturing, low-skilled services, and high-skilled services at a standardized level of non-agricultural employment share, set at 75%, as a proxy for the level of development. These results are depicted in Figure 16. The counterfactual outcomes closely mirror the data, indicating that variations in the initial sectoral productivity levels can effectively explain the observed heterogeneity in structural transformation. Specifically, the initial sectoral productivity levels account for 68% of the variation in manufacturing employment share, 81% of the variation in low-skilled services employment share, and 72% of the variation in high-skilled services employment share. On average, the initial sectoral productivity levels explain approximately 68% of the variance in sectoral employment shares across manufacturing, low-skilled services, and high-skilled services at the same level of development.

Figure 16: Sectoral Employment Share at 75% Non-Agricultural Employment Share: Counterfactual (assuming United States growth) vs. Model

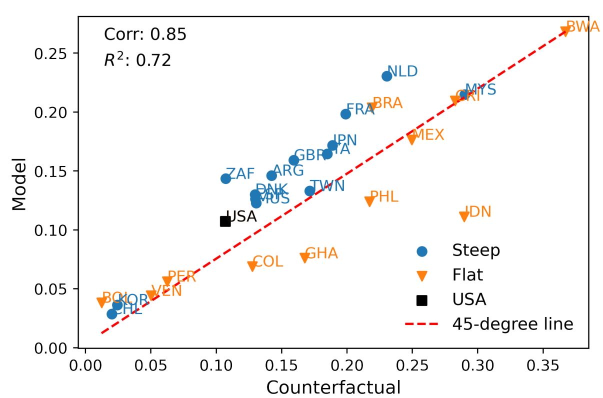
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



Notes: The counterfactual assumes each country's initial sectoral productivity level and the United States' sectoral productivity growth rates. Each plot reports the model-implied and counerfactual-implied employment share in manufacturing, low-skilled services and high-skilled services at 50% employment share in non-agricultural sector. The red dashed line represents the 45-degree line on which the counterfactual perfectly fits the data.

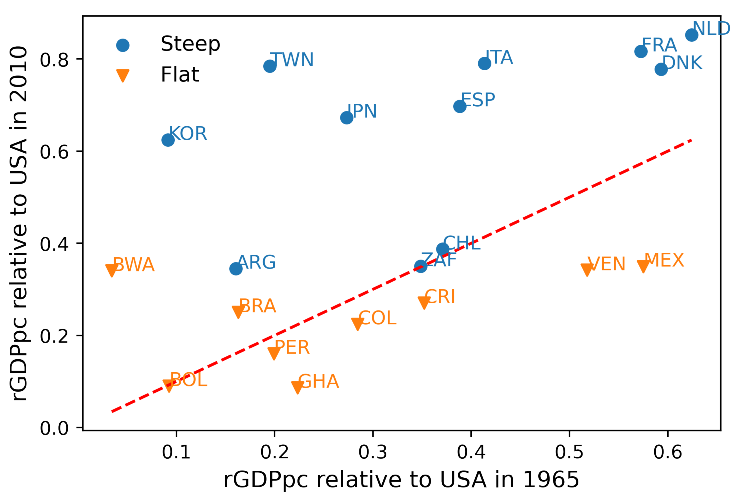
6 Aggregate Implications

In this section, I document cross-country patterns in aggregate labor productivity and investigate the quantitative importance of sectoral labor productivity in explaining cross-country growth experiences during the period 1965-2010. Due to sample limitation, only 20 among the 22 countries are included in the analysis.

6.1 Aggregate Productivity Growth Patterns

I first document the patterns in the aggregate labor productivity growth across countries. The data for the aggregate labor productivity are derived as follows. The aggregate labor productivity relative to the United States in 1965 is calculated based on PPP-adjusted real output and labor data from the Penn World Table (PWT) 10.0. Combining with the real aggregate productivity growth calculated based on the data from the GGDC 10-Sector Database, I then compute the aggregate labor productivity relative to the United States in 2010 for each country.

Figure 17: Aggregate Labor Productivity Relative to the United States: 1965-2010



Notes: Data on the aggregate labor productivity levels are computed from the Penn World Table 10.0. The plot reports the aggregate labor productivity level relative to the United States in 1965 and 2010. The dashed red line represents the 45-degree line on which the aggregate labor productivity levels relative to the United States in 1965 and 2010 are the same, indicating no catch-up in labor productivity with the United States.

Figure 17 plots the real aggregate labor productivity relative to the United States in 2010 against the values in 1965 as well as the 45-degree line to facilitate comparison. Most steep-manufacturing countries lie very far above the 45-degree line, indicating episodes of substantial catch-up in aggregate productivity relative to the United States. Most countries in the flat-manufacturing group lie very close to or below 45-degree line, suggesting experiences of no catch-up or stagnation relative to the United States.

6.2 Role of Sectoral Productivity in Aggregate Productivity

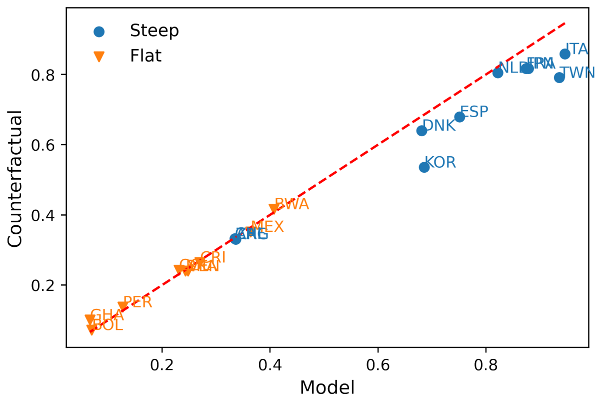
To investigate the contribution of productivity growth in each sector to aggregate productivity growth, I conduct four counterfactual experiments. In each counterfactual experiment, I set the productivity growth rate in one sector i to match that of the United States while keeping the growth rates of the other three sectors $j \neq i$ consistent with the data as follows. Utilizing sectoral productivity profiles from each counterfactual, I compute sectoral employment shares and aggregate productivity for each country. These results highlight the quantitative significance of sectoral productivity growth in explaining cross-country growth experiences. Figure 18 presents the counterfactual outcomes for aggregate labor productivity relative to the United States.

For most countries, aligning sectoral productivity growth rates in agriculture with those of the United States has minimal impacts on relative aggregate productivity. The counterfactual results, reported in Figure 18a, indicate a minor role of the agricultural sector in explaining the variation in cross-country growth experiences. Similarly, Figure 18d presents the counterfactual results for the high-skilled services sector, which also reveal negligible differences for most countries, except Denmark, Japan, and Taiwan. This outcome can be attributed to the relatively small size of the high-skilled services sector in most countries during the early and middle stages of development, coupled with the absence of a systematic pattern in high-skilled services productivity growth across countries.

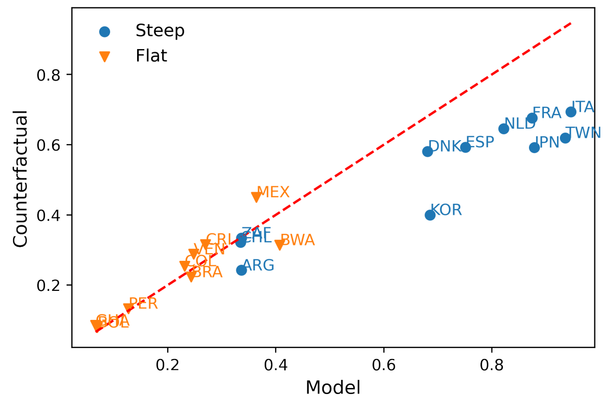
In Figure 18b, the results of the counterfactual using the manufacturing productivity growth rate in the United States are presented. This counterfactual yields significantly lower aggregate labor productivity levels for most steep-manufacturing countries. This disparity arises because, for steep-manufacturing countries, manufacturing employment share is substantial, and manufacturing productivity growth outpaces that of the United States. Conversely, for the flat-manufacturing group, minimal differences are observed. While these countries exhibit lower productivity growth in the manufacturing sector, their manufacturing employment share is low, thus mitigating the impact on aggregate stagnation experiences.

Figure 18: Aggregate Productivity Relative to the United States: Counterfactual vs. Data

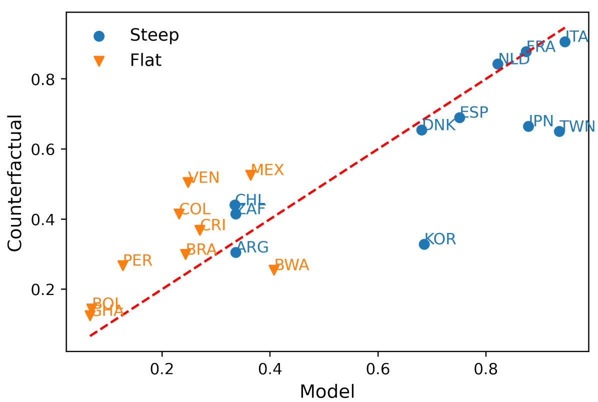
(a) Agriculture: $g_a = g_a^{US}$



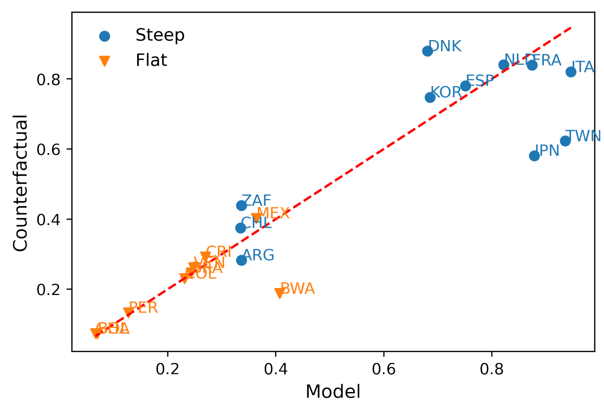
(b) Manufacturing: $g_m = g_m^{US}$



(c) Low-skilled Services: $g_{ls} = g_{ls}^{US}$



(d) High-skilled Services: $g_{hs} = g_{hs}^{US}$



Notes: Each counterfactual sets the productivity growth rate in each sector to the growth rate in the United States while keeping the other three sectors' growth rates the same as the data. Each plot reports the aggregate labor productivity levels relative to the United States in 2010 in the data and in each of the counterfactual. The red dashed line represents the 45-degree line on which the sectoral labor productivity levels relative to the United States in the data and the counterfactual are the same.

In Figure 18c, the counterfactual for low-skilled services sector illustrates a significantly large aggregate impact for most flat-manufacturing countries. The reason is that flat-manufacturing sector allocates substantially large share of employment towards low-skilled services and pproductivity growth is slow in low-skilled services. Therefore, the stagnation experience in aggregate outcome is mainly driven by low growth in low-skilled services. The low-skilled services productivity growth contributes little to the catch-up experiences in many steep-manufacturing countries (except countries with larger share of low-skilled services employment including Japan, Korea and Taiwan). The reason is that sectoral productivity growth in low-skilled services is close to the growth rate in the United States as shown in Figure 12c.

In Figure 18c, the counterfactual for the low-skilled services sector illustrates a significantly large aggregate impact for most flat-manufacturing countries. This is because the flat-manufacturing countries allocates a substantial share of employment to low-skilled services, where productivity growth is slow. Consequently, stagnation in aggregate outcomes is primarily driven by sluggish growth in low-skilled services in the flat-manufacturing countries. However, low-skilled services productivity growth contributes minimally to catch-up experiences in many steep-manufacturing countries, except for those with a larger share of low-skilled services employment, such as Japan, Korea, and Taiwan. This is due to the fact that sectoral productivity growth rates in low-skilled services are close to the growth rate in the United States, as depicted in Figure 12c.

In summary, the manufacturing and low-skilled services sectors emerge as the two primary contributors to the variation in cross-country growth experiences. Significant catch-up in manufacturing productivity, coupled with the prominence of the manufacturing sector, largely explains aggregate catch-up experiences in steep-manufacturing countries. Conversely, in flat-manufacturing countries, the absence of productivity growth in the low-skilled services sector, combined with its substantial size, constitutes crucial factors driving episodes of decline in aggregate productivity relative to the United States.

7 Discussion

In this section, I explore potential sources of cross-country variation in the initial relative productivity levels (static factors) between manufacturing and low-skilled services. I demonstrate that informality plays a dominant role in the low-skilled services sector, particularly in countries with flat-manufacturing patterns, while human capital exhibits a weak correlation with structural transformation.

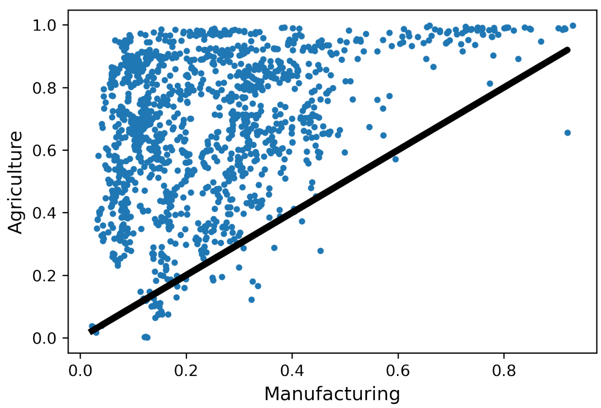
7.1 Informal Economy

The informal economy is widely recognized as a significant aspect of developing countries, characterized by small-scale production, limited physical and human capital, and low productivity. Key drivers of informality include weak institutions related to taxation, social security, bureaucracy, corruption, and the rule of law (Ulyssea, 2020).

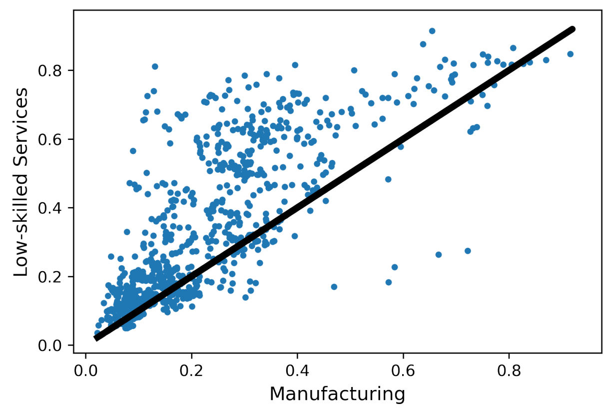
Various definitions and measures of informality exist depending on the specific context. For the purpose of this paper, which aims to document cross-country patterns across both developed and developing economies, self-employment serves as the primary proxy for the degree of informality (Elgin et al., 2021). Data are sourced from the International Labour Organization (ILO) Database, covering employment by economic sector and employment status. Employment data are aggregated into four sectors: agriculture, manufacturing, low-skilled services, and high-skilled services. For each sector, the self-employment share at the sectoral level is computed by dividing the number of workers with self-employed status by the total number of workers within that sector.

Figure 19: Self-Employment Share by Sector

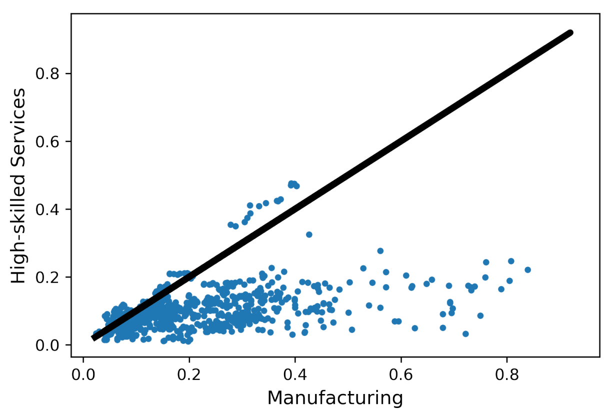
(a) Agriculture vs. Manufacturing



(b) Low-skilled Services vs. Manufacturing



(c) High-skilled services vs. Manufacturing

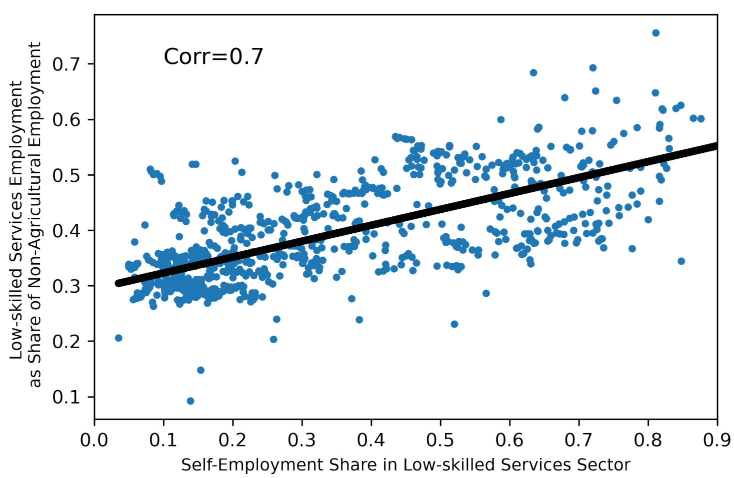


Notes: Data on the self-employment share are from the International Labour Organization (ILO) Database. The solid black line represents the 45-degree line on which the self-employment share in agriculture/low-skilled services/high-skilled services are the same as in manufacturing.

Figure 19 illustrates the self-employment share in agriculture, low-skilled services, and high-skilled services plotted against manufacturing, respectively. The solid black line in the figures represents the 45-degree line. Figures 19a and 19b demonstrate that the self-employment share in agriculture and low-skilled services is higher than in manufacturing (lying above the 45-degree line) for most countries. Conversely, the high-skilled services sector exhibits lower self-employment share than manufacturing, as depicted in Figure 19c. This evidence suggests significant variation in self-employment share across sectors, with agriculture and low-skilled services tending to be more informal, while manufacturing and high-skilled services are generally more formal.

Figure 20 exhibits the relationship between the employment share of low-skilled services in non-agriculture and the self-employment share in low-skilled services across countries. The share of low-skilled services in non-agricultural sectors is computed by dividing the employment in low-skilled services by the non-agricultural employment. This measure serves as a proxy for the structural transformation pattern: A higher value indicates a higher share of labor leaving agriculture reallocating towards low-skilled services (closer to flat-manufacturing patterns). The reason for using the low-skilled services employment share instead of the manufacturing employment share is that the manufacturing employment share with respect to non-agriculture differs significantly in the industrialization and the deindustrialization due to the hump-shaped evolution. Instead, the employment share of low-skilled services rises over the course of development and exhibit a robust relationship respect to the non-agricultural employment share. Considering the sample consisting of 156 countries at various income levels, share of low-skilled services with respect to non-agriculture consequently better captures the heterogeneity in cross-country structural transformation patterns.

Figure 20: Low-skilled Services - Employment Share vs. Informality



Notes: The plot reports the employment of low-skilled services as share of non-agricultural employment and the self-employment share in low-skilled services sector across countries. Solid line represents the fitted regression line between the two variables.

Figure 20 underscores a robust correlation (approximately 0.7) between the degree of informality in the low-skilled services sector and the employment share of low-skilled services. Countries exhibiting higher self-employment shares (indicating a greater degree of informality) tend to allocate more labor towards low-skilled services. This evidence suggests that in nations with sizable informal sectors, the low-skilled services sector tends to absorb informal workers transitioning from agriculture, resulting in lower productivity levels due to the predominance of small-scale informal production.

One example of a distortion contributing to high informality and low productivity levels in low-skilled services relative to manufacturing is high barriers to entry and/or high business operation costs. In an economy characterized by substantial fixed costs associated with starting and running a business, only a limited number of highly productive firms can cover these costs and operate profitably. Among the existing firms, more are likely to operate in the manufacturing sector, given its typically larger scale of operations compared to low-skilled services. Consequently, most production units in low-skilled services are informal, small-scale household enterprises with inherently lower productivity levels. This phenomenon illustrates how distortions can widen the productivity gap between manufacturing and low-skilled services in flat-manufacturing countries.

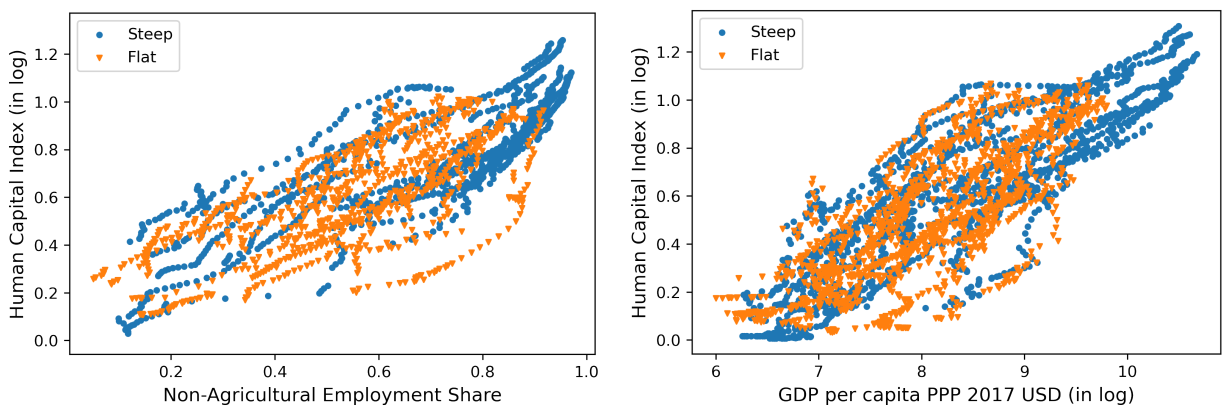
7.2 Human Capital

Human capital endowment, or the supply of skilled labor, emerges as a potential factor in explaining the significant heterogeneity in employment allocation between manufacturing and low-skilled services. One might question whether flat-manufacturing countries, characterized by a notably large low-skilled services sector, suffer from a low level of human capital or a scarcity of skilled labor. However, my findings indicate little correlation between human capital and the diversity observed in structural transformation patterns.

Figure 21 displays the logarithm of the Human Capital Index (HCI) plotted against two different measures of development level: non-agricultural employment share and the logarithm of GDP per capita (PPP 2017 USD). Generally, human capital tends to increase with development. Interestingly, there is no consistent difference in the human capital index between steep- and flat-manufacturing countries. In other words, flat-manufacturing countries do not systematically demonstrate lower human capital indices. At various levels of development, there appears to be little correlation between the human capital index and the employment share of manufacturing. These findings suggest a lack of evidence supporting the role of human capital (as measured by schooling) in explaining the significant heterogeneity observed in structural transformation patterns across countries.

Figure 21: Human Capital Index across Economies

(a) Non-AGR Employment Share (b) Real GDP per capita PPP 2017 USD (in log)



Notes: Data on Human Capital Index are from provided by the Penn World Table 10.0, based on years of schooling and returns to education.

8 Conclusions

This paper documents significant heterogeneous features in structural transformation patterns across countries. In particular, while some countries experience steep hump-shaped patterns in manufacturing sector, others experience flat profiles with small changes in manufacturing employment share. The steep-manufacturing countries experience substantial labor reallocation of employment from agriculture to manufacturing during the industrialization phase and substantial reallocation from manufacturing to high-skilled services during the deindustrialization phase. The flat-manufacturing countries remains low level of the manufacturing employment share and exhibit unnoticeable distinction between the industrialization and the deindustrialization. The structural transformation pattern in the flat-manufacturing countries can be characterized by substantial reallocation of employment from agriculture to low-skilled services and little change in manufacturing sector.

Based on a standard model of structural change, my analysis highlights the role of heterogeneous sectoral labor productivity profiles in capturing the cross-country differences in the structural transformation process and the aggregate productivity. Among factors driving the sectoral labor productivity, the initial sectoral productivity levels can account for the majority of variation in structural transformation patterns. Country-specific institutions and distortions related to the degree of informality are potential sources explaining the lower productivity level and a larger size of low-skilled services relative to manufacturing in the flat-manufacturing countries.

I also investigate the aggregate implications of the heterogeneous structural transformation paths. While the steep-manufacturing countries experience substantial aggregate productivity catch-up, the flat-manufacturing countries tend to experience no catch-up or decline in aggregate labor productivity relative to the United States. The substantial catch-up episodes in the steep-manufacturing countries mainly result from catch-up in manufacturing productivity. The lack of aggregate productivity growth in the flat-manufacturing countries can be largely accounted by the low productivity growth of low-skilled services sector. Differences in the agricultural and high-skilled services productivity growth contribute little to the aggregate growth experiences across countries.

These findings suggest that understanding country-specific sources of institutions and distortions driving sectoral productivity is crucial to understanding the heterogeneous paths of structural transformation and the consequences on aggregate growth across countries. An important question is why the flat-manufacturing countries have a substantially low productivity level in low-skilled services relative to manufacturing. It will be valuable to further investigate and quantify the importance of various sources of country-specific frictions and distortions in driving the substantial productivity gap between manufacturing and low-skilled services in the flat-manufacturing countries. It will be also important to extend the analysis to open economy framework to understand how trade interacts with country-specific factors in driving the process of structural transformation and growth experiences.

References

Boppart, T. (2014). Structural Change and the Kaldor Facts in a Growth Model with Relative Price Effects and non-Gorman Preferences. *Econometrica*, 82(6):2167–2196.

Buera, F. J. and Kaboski, J. P. (2009). Can Traditional Theories of Structural Change Fit the Data? *Journal of the European Economic Association*, 7(2-3):469–477.

Buera, F. J., Kaboski, J. P., Rogerson, R., and Vizcaino, J. I. (2021). Skill-Biased Structural Change. *The Review of Economic Studies*.

Carter, S., Gartner, S., Haines, M., Olmstead, A., and Sutch, R. (2006). Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition.

Comin, D., Lashkari, D., and Mestieri, M. (2021). Structural Change with Long-run Income and Price Effects. *Econometrica*, 89(1):311–374.

de Vries, G., Arfelt, L., Drees, D., Godemann, M., Hamilton, C., Jessen-Thiesen, B., Kaya, A., Kruse, H., Mensah, E., and Woltjer, P. (2021). The Economic Transformation Database (ETD): Content, Sources, and Methods. Technical report, WIDER Technical Note 2/2021.

Duarte, M. and Restuccia, D. (2010). The Role of the Structural Transformation in Aggregate Productivity. *The Quarterly Journal of Economics*, 125(1):129–173.

Duarte, M. and Restuccia, D. (2020). Relative Prices and Sectoral Productivity. *Journal of the European Economic Association*, 18(3):1400–1443.

Duernecker, G., Herrendorf, B., and Valentinyi, A. (2021). Structural Change within the Service Sector and the Future of Baumol's Cost Disease. CEPR Discussion Paper 12467.

Elgin, C., Kose, M. A., Ohnsorge, F., and Yu, S. (2021). Understanding Informality. Technical report.

Fang, L. and Herrendorf, B. (2021). High-Skilled Services and Development in China. *Journal of Development Economics*, 151:102671.

Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, 105(10):3150–82.

Gollin, D., Parente, S., and Rogerson, R. (2002). The Role of Agriculture in Development. *American Economic Review*, 92(2):160–164.

Gollin, D., Parente, S. L., and Rogerson, R. (2007). The Food Problem and the Evolution of International Income Levels. *Journal of Monetary Economics*, 54(4):1230–1255.

Herrendorf, B., Rogerson, R., and Valentinyi, A. (2014). Growth and Structural Transformation. In *Handbook of Economic Growth*, volume 2, pages 855–941. Elsevier.

Huneeus, F. and Rogerson, R. (2023). Heterogeneous Paths of Industrialization. *The Review of Economic Studies*, page rdad066.

Kongsamut, P., Rebelo, S., and Xie, D. (2001). Beyond Balanced Growth. *The Review of Economic Studies*, 68(4):869–882.

Ngai, L. R. and Pissarides, C. A. (2007). Structural Change in a Multisector Model of Growth. *American Economic Review*, 97(1):429–443.

Ngai, R. and Sevinc, O. (2020). A Multisector Perspective on Wage Stagnation. CEPR Discussion Paper No. DP14855.

Rodrik, D. (2016). Premature Deindustrialization. *Journal of Economic Growth*, 21(1):1–33.

Rogerson, R. (2008). Structural Transformation and the Deterioration of European Labor Market Outcomes. *Journal of Political Economy*, 116(2):235–259.

Sposi, M., Yi, K.-M., and Zhang, J. (2021). Deindustrialization and Industry Polarization. Working Paper 29483, National Bureau of Economic Research.

Timmer, M., de Vries, G. J., and De Vries, K. (2015). *Patterns of Structural Change in Developing Countries*. Routledge.

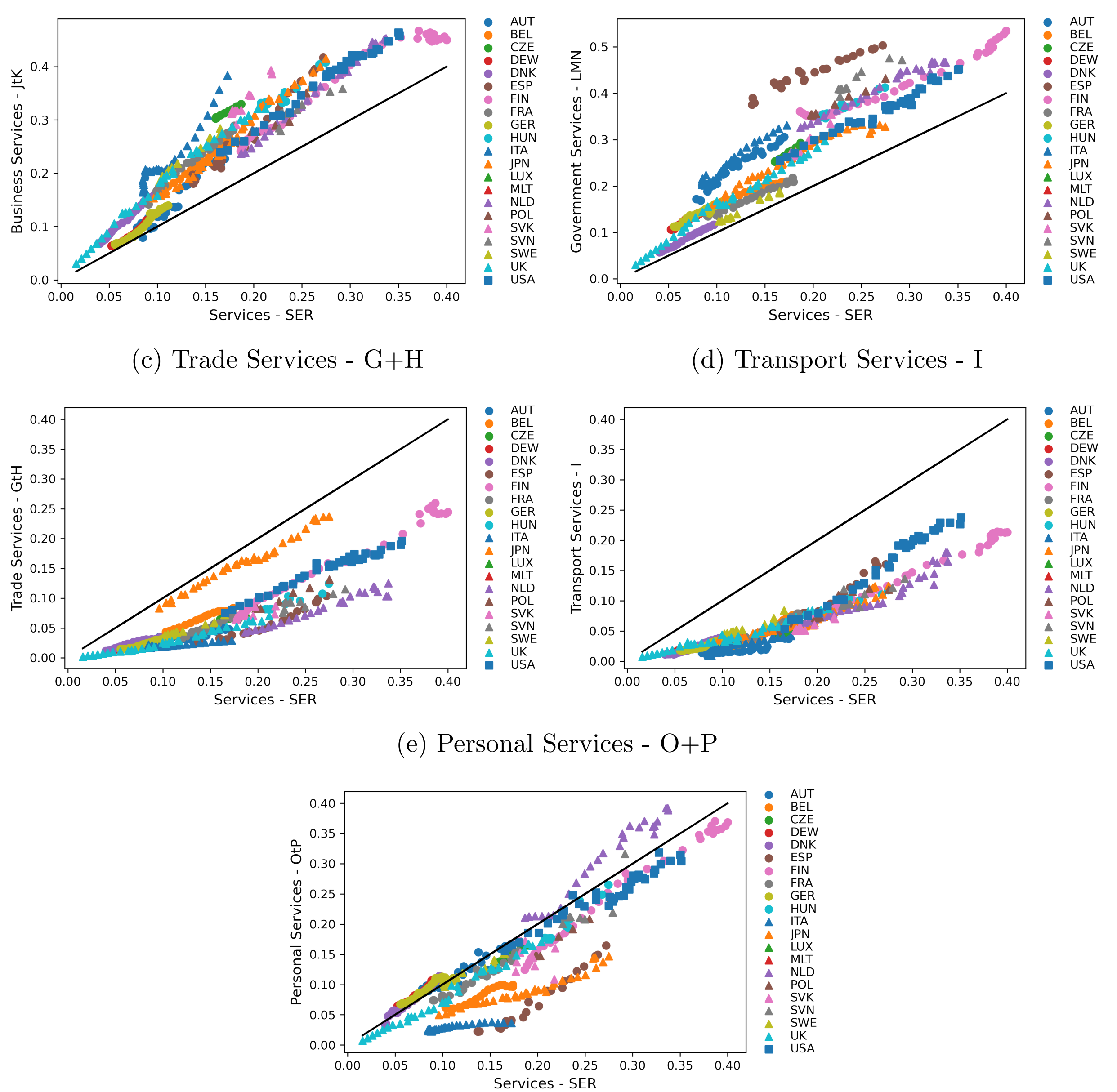
Timmer, M. P., O Mahony, M., Van Ark, B., et al. (2007). EU KLEMS Growth and Productivity Accounts: An Overview. *International Productivity Monitor*, 14:71.

Ulyssea, G. (2020). Informality: Causes and Consequences for Development. *Annual Review of Economics*, 12:525–546.

Online Appendix

A Services Classifications - KLEMS

Figure A.1: High-skilled Labor Hour Share



(a) Business Services - J+K

(b) Government Services - L,M,N

(c) Trade Services - G+H

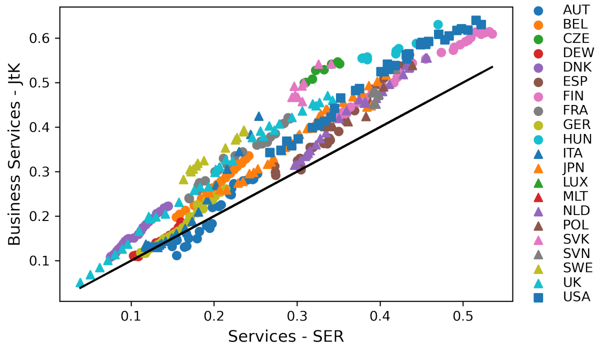
(d) Transport Services - I

(e) Personal Services - O+P

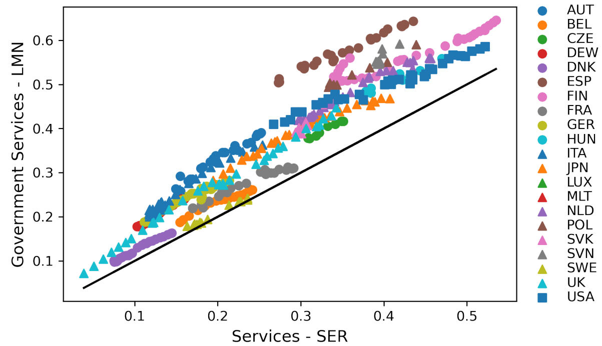
Notes: High-skilled worker is defined as worker with education with at least bachelor-equivalent degree. Data on share of hours worked by high-skilled workers for each sector are from KLEMS Database. The solid black line represents the 45-degree line on which the hour share of high-skilled labor in the sector is the same as the median of broad services sector.

Figure A.2: High-skilled Labor Compensation Share

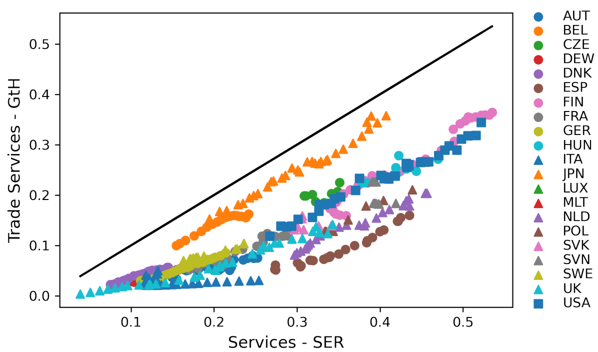
(a) Business Services - J+K



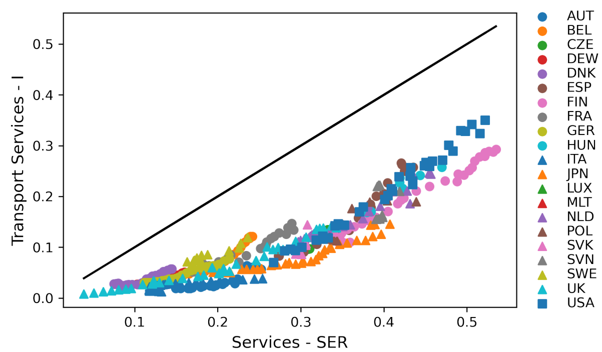
(b) Government Services - L,M,N



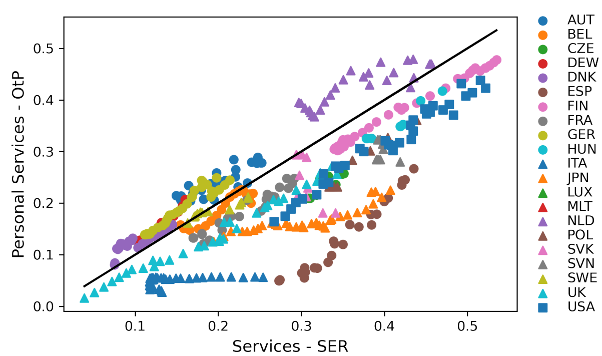
(c) Trade Services - G+H



(d) Transport Services - I



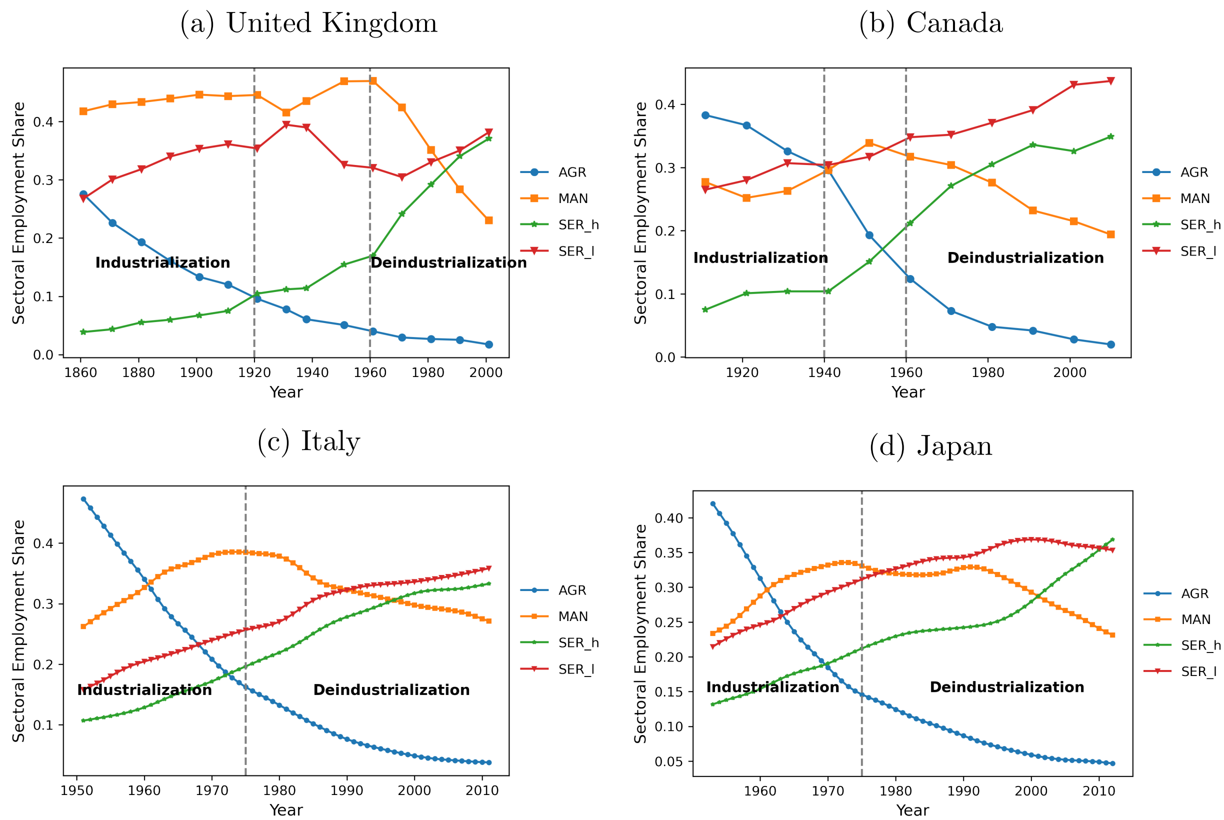
(e) Personal Services - O+P



Notes: High-skilled worker is defined as worker with education with at least bachelor-equivalent degree. Data on the share of labor compensation by high-skilled workers for each sector are from the KLEMS 2007 Database. The solid black line represents the 45-degree line on which the labor compensation share of high-skilled labor in the sector is the same as the median of broad services sector.

B Examples of Structural Transformation Patterns

Figure B.1: Examples of Structural Transformation in Steep-Manufacturing Economies

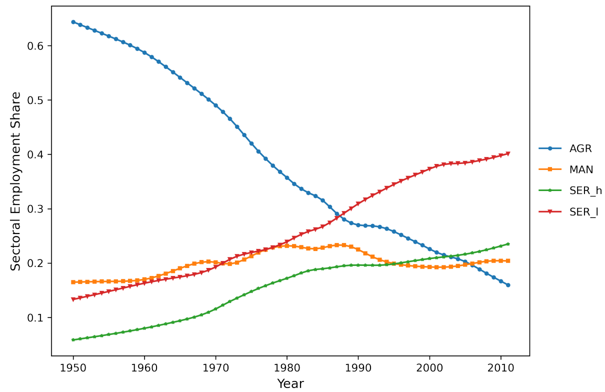


(a) United Kingdom (b) Canada (c) Italy (d) Japan

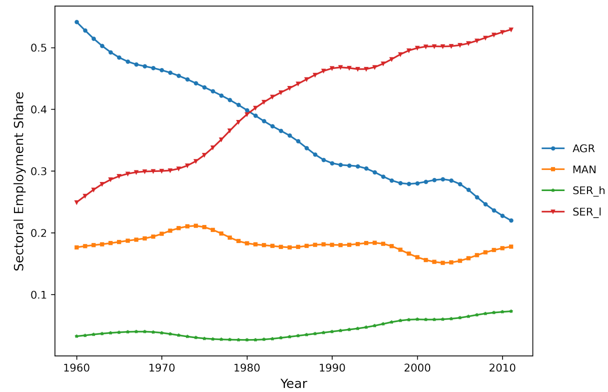
Notes: Data for United Kingdom are from Professor Charles Feinstein's (1972) National Income, Output And Expenditure Of The United Kingdom 1855-1965 and from the GDDC 10-Sector Database. Data for Canada are from Statistics Canada. Data for Italy and Japan are from the GDDC 10-Sector Database.

Figure B.2: Examples of Structural Transformation in Flat-Manufacturing Economies

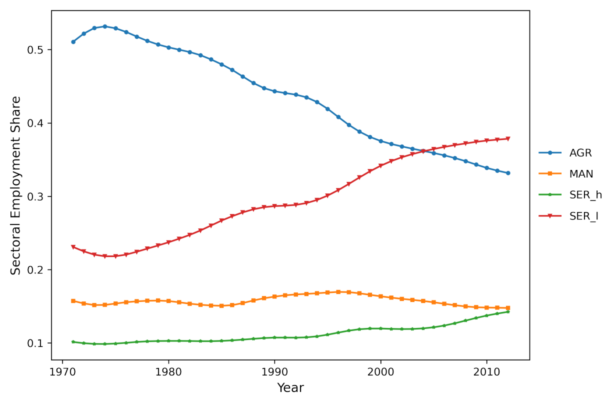
(a) Brazil



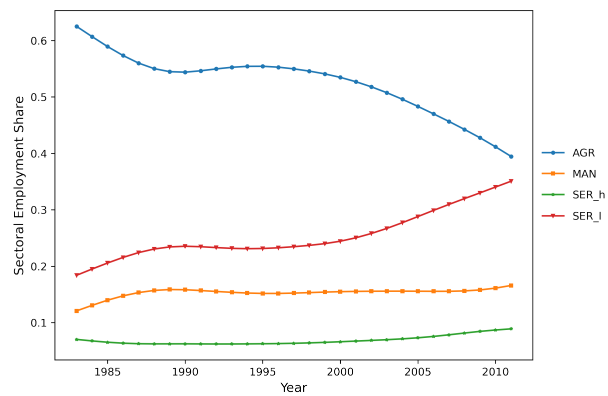
(b) Peru



(c) Philippines



(d) Ghana



Notes: Data on sectoral employment shares are from the GDDC 10-Sector Database.